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XXI.

Report on the Anthozoa, and on some additional Species dredged by the "Blake" in 1877–1879, *and by the U. S. Fish Commission Steamer "Fish Hawk" in* 1880–82. By A. E. VERRILL.

IN order to make the following report more complete, all the species of Anthozoa dredged by the U. S. Fish Commission, during the past three seasons, in deep water along the Gulf Stream Slope, off the southern coast of New England and off Chesapeake Bay, have been combined with those dredged by the Blake along the whole coast, from off South Carolina to George's Bank. A large proportion of the species were dredged both by the Blake and by the Fish Hawk, but the collections made by the latter are much the largest, and contain a number of species not taken by the Blake. Other species, poorly represented in the collections of the Blake, were secured in large numbers, and of various ages, by the Fish Hawk. Moreover, the dredgings by the Fish Hawk having been made under the immediate supervision of the author, they have afforded him opportunities to study and make descriptions of many of the species from living specimens. Most of the drawings of the Actinians were also made by Mr. J. H. Emerton from living specimens obtained by the Fish Hawk, and kept alive in our aquaria. For the use of those drawings, on this occasion, we are indebted to the kindness of Professor S. F Baird, U. S. Commissioner of Fish and Fisheries.

A few deep-water species, that have been obtained only by the Gloucester fishermen on the deep fishing grounds off Nova Scotia and Newfoundland, and by them presented to the U. S. Fish Commission, have also been introduced, to make the list more complete. From these

sources nearly all the species known to inhabit the Atlantic coast of North America, in deep water, have been derived. The "Challenger" took a few additional species, mostly in still deeper waters, at a greater distance from the coast. The present report includes, therefore, nearly all the Anthozoa hitherto discovered in depths between 100 and 1,200 fathoms, along the Gulf Stream Slope, off the coast extending from South Carolina to Cape Cod. A few well-known, more northern, deep-water species, like *Primnoa reseda* and *Paragorgia arborea*, not yet known except from the fishing banks, off Nova Scotia and northward, have been omitted, together with other northern forms that inhabit the shallower waters of New England, but extend downward beyond 100 fathoms. Among these are *Cerianthus borealis* V., *Urticina crassicornis*, *Metridium dianthus* (*marginatum*), *Bolocera multicornis*, *Cornulariella modesta*, &c. As the writer is about to print * a more detailed and illustrated report on all the Anthozoa of New England and the British Provinces, it was not thought desirable to include such species, when not in the Blake collections. Several West Indian species, mostly new, from the Blake collections of 1877–79, have been included in this report for the purpose of comparison with the northern forms, and more fully to illustrate the characters of the two families, *Ceratoisidæ* and *Dasygorgidæ*, nov., to which most of the southern species referred to belong. West Indian species, belonging to *Paramuricea* and *Acanthogorgia*, are also described for comparison with the related species from our coast.

ALCYONARIA.

PENNATULACEA.

Pennatula aculeata Danielssen & Koren.

Pennatula aculeata Danielssen, Forhandl. Vidensk.-Selsk., Christiania, 1858, p. 25; Fauna Littoralis Norvegiæ, III., 1877, p. 86, pl. 11, figs. 8, 9.
Verrill, Amer. Jour. Sci., V., 1873, pp. 5, 100; XXIII., 1882, pp. 310, 315.
Smith & Harger, Trans. Conn. Acad., III., 1876, p. 54.
Pennatula phosphorea, var. *aculeata* Sars; Kölliker, Alcyonarien, I., Pennatuliden, 1870, p. 134, pl. 9, fig. 73.
Pennatula Canadensis Whiteaves, Ann. & Mag. Nat. Hist., X., 1872, p. 346.

Plate I. Figs. 2, 2 a.

This species varies considerably in form, according to the state of expansion. The stem is somewhat larger and bulbous at the end, and sometimes the swell-

* In the Reports of the U. S. Fish Commission.

ing occurs at its upper part. The body or middle part of the rachis is sometimes considerably swollen, though in alcoholic specimens it is contracted and thin. There are a large number of small zoöids, with many more or less large, acute, spiniform, and spiculose processes among them; these are often long and conspicuous. The alæ are also variable in form. They are usually long and narrow, with a single row of spinose calicles along the edge; the edge is sometimes deeply divided between the calicles, or even lacerate.

The polyps (Fig. 2 a), in life, when fully expanded, have long, slender, tapering, acute tentacles, with numerous slender pinnæ, the distal ones gradually becoming very short; stem of tentacles dark red, pinnæ pale rose or whitish. The tentacles come out in the interval between the groups of spines on the edge of the calicles. When not fully extended the tips and pinnæ are incurved, and therefore appear obtuse (Figs. 2 a, 2 b).

Off Martha's Vineyard, we dredged, on the Fish Hawk, a rose-colored variety (var. *rosea* Dan.) at several localities. In one instance we also took a pure white specimen (var. *alba* V.), at Station 1025, in 216 fathoms. This is doubtless only an albino. The color is usually deep red, with the stalk rosy, becoming yellowish white at the base.

Specimens dredged by the Blake in 1880 : —

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
305	810	41° 33′ 15″	65° 51′ 25″	32 large and small.
306	524	41° 32′ 50″	65° 55′	2 small.
310	260	39° 59′ 16″	70° 18′ 30″	Many young.
326	464	33° 42′ 15″	76° 0′ 50″	3 young.
336	197	38° 21′ 50″	73° 32′	5 small.

This species is very abundant and widely distributed on our coasts, in 100 to 487 fathoms, on soft muddy bottoms. Gulf of St. Lawrence, 160–200 fathoms, — Whiteaves, 1871–73; Gulf of Maine, — U. S. Fish Commission, on the "Bache," 1872–73; Grand Bank, St. Peter's Bank, Banquereau, Western Bank, and other banks off Nova Scotia, in 60 to 300 fathoms, — Gloucester fishermen (in 29 lots, including about 90 specimens); off Cape Sable, N. S., 88 fathoms, — U. S. Fish Commission; off Martha's Vineyard and Block Island, and off Chesapeake and Delaware Bays, 1880, 1881, 1882, in 100–487 fathoms, — U. S. Fish Commission. Several hundreds of specimens were taken at each of the Stations 943, 945, 1025.

Christiansund, 30–100 fathoms, — Sars and Danielssen; Eastern Atlantic, 300 fathoms, — Carpenter and Thomson.

Pennatula (Ptilella) borealis Sars, sp.

Pennatula grandis Ehrenberg, Corall. rothen Meeres, 1832, p. 66 (*non* Pallas).
Kölliker, Zoöl. Voy. Challenger, I., Pt. II., 1881, p. 4.
Pennatula borealis, Sars, Fauna Lit. Norvegiæ, I., 1856, p. 17, pl. 2, figs. 1–4.
Kölliker, Pennatuliden, I., p. 136.
Verrill, Amer. Jour. Sci., XVI., 1878, p. 375; XXIV., Nov. 1882, p. 364.

Ptilella borealis GRAY, Catalogue of Sea Pens, p. 21.
VERRILL, Amer. Jour. Sci., XVII., 1879, p. 241.
Ptilella grandis KOREN & DANIELSSEN, Fauna Lit. Norvegiæ, 1877, p. 82, pl. 11, figs. 1–7 (*non* Pallas, sp.).
Pennatula (Ptilella) borealis VERRILL, Amer. Jour. Sci., XXIII., 1882, p. 310.

This very large and handsome species is common on the deep-water fishing grounds off Nova Scotia and Newfoundland. From the Gloucester fishermen over 120 specimens, mostly of large size, have been received by the U. S. Fish Commission, all of which have been examined by me. These were received in 83 lots, from 1878 to 1881. They were taken in 120 to 350 fathoms, on the outer slopes of the Grand Bank, St. Peter's Bank, Western Bank, Banquereau, Sable Island Bank, Le Have Bank, and George's Bank. Previously, it was known from only a few Norwegian specimens, from Christiansund, Bergensfjord, Lofoten, Banenfjord, etc., in 150 to 200 fathoms.

A young specimen was dredged by the U. S. Fish Commission, off Nantucket and Martha's Vineyard, in 224 fathoms, in 1881; also three large and perfect specimens, in 317 and 640 fathoms, and a very young one, in 192 fathoms, in 1882. One of the largest of these was 530 mm. (about 20.5 inches) high, and 146 mm. broad; length of the largest wings, 64 mm.; their breadth, 38 mm.; diameter of bulb, 38 mm.; length of stem, below the bulb, 112 mm. Color of the wings and rachis, in life, deep orange; upper surface of bulb, orange-red.

Among our specimens there is considerable variation in the relative size of the wings and in their form; in some cases they are long and acute-triangular; in others, they are much broader and not acute. The color varies from dull orange-yellow to deep orange-red.

Balticina Finmarchica (SARS) GRAY.

Virgularia Finmarchica M. SARS, Fauna Lit. Norvegiæ, II., p. 68, pl. 11.
Balticina Finmarchica GRAY, Catalogue of Sea Pens, p. 13.
VERRILL, Amer. Jour. Sci., XVI., 1878, p. 375; XXIII., 1882, pp. 311, 315.
Stylatula Finmarchica RICHIARDI, Monografia della Fam. Pennatularii, 1869, p. 69.
Pavonaria Finmarchica KÖLLIKER, Pennatuliden, 1871, p. 243 (*non Pavonaria* Cuvier).

Plate I. Figs. 3, 3 a.

A young specimen of this species, in the collection, is 70 mm. long; 3 mm. broad, across the polypiferous part; the barren peduncle is 35 mm. long; 2 mm. in diameter. Where most developed, there are two polyps in each oblique row, supported by two-lobed spiculose calicles; between the wings there are four to six scattered zoöids. Toward the upper part of the peduncle there is but one well-developed polyp, with or without an additional young bud, in the oblique rows; and here the calicles have the apex bilobed only slightly, or not at all and terminating in a single pointed group of spicula. This part agrees

essentially in structure with the genus *Microptilum* Kölliker (Challenger Voyage, Pennatulida, p. 26).

Another specimen is abnormal; it is 71 mm. long, the peduncle occupying 40 mm. There are about fifteen transverse rows of polyps on each side, but the uppermost ones are small, imperfectly developed, and pale, as if in process of restoration after they had been injured or destroyed. The middle rows have about five well-developed polyps, resembling those on much larger specimens.

In life the color of the polyps is dark purplish brown; stem and rachis, pale salmon; base of stem, orange.

This species often has the upper part of the axis, for a greater or less extent, denuded, and occupied by one or more specimens of an actinian (*Actinauge nexilis*, Plate VI. figs. 4, 5). Sometimes the denuded place thus occupied is not terminal, but along some part of the rachis. I have seen specimens with an actinian only 3 or 4 mm. in diameter attached to a small bare spot on the side of the rachis, but its broadly expanded base had already insinuated itself beneath the cœnenchyma, and completely clasped the axis of the *Balticina*. This actinian has, in a remarkable degree, the habit of thus clasping the axis of this polyp, and other similar objects, by its base, and the edges of the basal disk, when they meet, unite together in a suture. When two or more are attached near together, their margins unite where they come in contact.

Specimens dredged by the Blake in 1880 : —

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
307	980	41° 29′ 45″	65° 47′ 10″	1 young.
310	260	39° 59′ 16″	70° 18′ 30″	1 injured and dwarfed.

Several specimens were trawled by the U. S. Fish Commission, off Martha's Vineyard, in 160 to 238 fathoms, in 1880, 1881, and 1882. The Gloucester fishermen have presented many large and fine specimens (more than 75), some of them over two feet long. These came in 57 lots, from the outer slopes of the Grand Bank and all the banks off the Nova Scotia coast, in 60 to 400 fathoms. It was previously known from off Finmark, 240 fathoms; Bergenfjord, 300 fathoms.

Anthoptilum grandiflorum Verrill.

Virgularia grandiflora Verrill, Amer. Jour. Sci., XVII., March, 1879, p. 239.
Anthoptilum Thomsoni Kölliker, Zoöl. Voy. Challenger, Pennatulida, 1881, p. 13, pl. 5, figs. 16–18.
Anthoptilum grandiflorum, Verrill, Amer. Jour. Sci., XXIII., 1882, pp. 312, 315.

Plate I. Fig. 6.

This large species was dredged by the Blake, off North Carolina, in 603 and 647 fathoms, in 1880. A specimen, apparently identical, had previously been taken by the Blake, off Guadeloupe, in 734 fathoms, in 1878–79.

List of specimens dredged by the Blake in 1878–80 : —

Station.	Fathoms.	Locality.	Specimens.
173	734	Off Guadeloupe.	1 medium size.
325	647	N. Lat. 33° 35′ 20″, W. Long. 76°	1 good size.
329	603	" 34° 39′ 40″, " 75° 14′ 40″	1 " "

Taken also by the U. S. Fish Commission, off Martha's Vineyard, in 302 to 310 fathoms. Its color, in life, is usually deep salmon-brown, but varies to pale salmon, and even to yellowish white.

The Gloucester fishermen have presented to the U. S. Fish Commission about forty specimens, in twenty lots. These are from near the Grand Bank, St. Peter's Bank, Western Bank, Banquereau, Sable Island Bank, and Le Have Bank, in 85 to 300 fathoms.

In the Zoölogy of the Challenger,* Dr. Kölliker described *A. Thomsoni*, from off Buenos Ayres, in 600 fathoms. It is a large species, apparently identical in all respects with my species, from off Nova Scotia and New England.

Funiculina armata Verrill.

Funiculina armata Verrill, Amer. Jour. Sci., XVII., 1879, p. 240; XXIII., 1882, pp. 312, 315.

Plate I. Figs. 4, 4 a, 4 b.

Rachis long, slender, with large, urceolate, rigid, spiculose polyp-calicles, armed at the aperture with eight sharp, divergent, spiculose points. Axis and rachis quadrangular, the sides of the axis concave. The polyp-calicles are entirely separate and arranged in numerous irregular, transverse clusters, of two to four smaller and larger ones intermingled; they are so stiffened by spicula as to be scarcely flexible, and retain well their form; they are elongated, swelling out gradually from near the base, and tapering again above the middle, to near the summit, which suddenly expands to the edge, from which eight acute, rigid, white points diverge. The tentacles are spiculose, but wholly retractile within the calicles; they are situated between the divergent points of the calicles, in expansion.

The zoöids are scattered along the middle of the polypiferous side of the rachis, and also between the rows of polyps; they are prominent and rather large, though much smaller than the polyps, contracted at the base and enlarged at the end, with eight rudimentary tentacles.

Stem light brownish yellow or buff at base, becoming orange-brown or dark purplish above; calicles dark reddish brown or deep purple, the whitish spicula visible in eight chevron lines; zoöids pale yellow or light salmon with purplish stripes; tentacles dark brownish red.

* The Zoölogy of the Voyage of H. M. S. Challenger, Vol. I. Part II., Report on the Pennatulida, by Professor Albert V. Kölliker, 1880.

Height, 600 mm.; diameter of rachis, near base, 1.5 mm.; in middle, about 1 to 1.5 mm.; length of larger polyp-calicles, about 6 mm.; diameter, 1.5 to 1.75 mm. Larger ones have been obtained.

The spicula (Fig. 4 a) of the calicles are long and slender, prismatic, with strong lateral angles, or ribs, which are a little winding; they usually taper a little to the ends, which are not very acute. The larger ones measure .92 by .04, .82 by .05, .82 by .037, .80 by .03, .50 by .03 mm.

This was first described from a specimen taken in December, 1878, in 300 to 400 fathoms, about forty miles southwest from the N. W. Light of Sable Island, N. S., by George K. Allen, of the schooner "M. H. Perkins." Other specimens were afterwards brought in by the Gloucester fishermen, from the fishing banks off Nova Scotia.

Two specimens were dredged by us, on the U. S. Fish Commission steamer Fish Hawk, in 1880, off Martha's Vineyard, in 252 and 325 fathoms.

It was dredged by the Blake in 1878–79, in the Caribbean Sea.

List of specimens dredged by the Blake, 1878–79: —

Station.	Fathoms.	Locality.	Specimens.
135	450	Off Santa Cruz.	4 small.
136	508	" "	2 small.
163	769	Off Gaudeloupe.	1 l. broken.

Kophobelemnon scabrum Verrill, sp. nov.

Plate I. Figs. 5, 5 a, 5 b, 5 c.

Body clavate, with a long stem, swollen above. About eight large prominent polyps are rather irregularly arranged on the two sides and in front, near the top, leaving a naked band on the backside, which is covered with small prominent zoöids. Similar zoöids occur between the polyps, and entirely surround the rachis, below the polyps, and eight longitudinal rows run down on the stem; four of the rows are longer than the others, and extend over the swollen part of the stem. The stem terminates in a bulb, at the base, which is sulcated by several grooves in our example; above the bulb it is slender, and then gradually swells into the bulbous portion, a short distance below the polyps; the surface is finely spiculose. The polyps arise from the summits of large, swollen, mamillary elevations; some of them are entirely retracted, but most of them have the lower part of the body exposed, in the form of a strongly eight-ribbed, verruciform tubercle, which is densely spiculose, like all other external parts. The zoöids are rather large, obliquely appressed, and directed upward; they vary considerably in size. Axis round, slender, extending from the apex to near the base. Color in alcohol, light gray.

Height, 56 mm.; breadth across body, 8 mm.; diameter of swollen part of stem, 2.5 mm.; diameter of contracted polyps, 3 mm.

The integument is firm and coriaceous, with a rough surface, owing to an abundance of small slender spicula, which lie at various angles and in several

strata; these are small, fusiform or oblong rods and prisms. Some of them are long, slender, triquetral, and nearly smooth (Fig. 5 b, *d*), or sparingly warted near the ends; the larger of these measure .35 by .03 mm. to .29 by .03 mm. Others are shorter, more rod-like, and covered with scattered, minute, conical, obtuse warts (Fig. 5 c); some of these are swollen in the middle with prominent warts; most of them are roughened and obtuse at the ends; they measure .25 by .025, .23 by .025, .20 by .03, .20 by .025, .15 by .02, .14 by .015 mm. Some of smaller size (.10 by .015 mm.), but similar in form, are strongly warted all over (Fig. 5 b, *e*).

A single specimen was taken south of George's Bank, at Station 307, in 980 fathoms, N. Lat. 41° 29′ 45″, W. Long. 65° 47′ 10″.

Distichoptilum Verrill.

Amer. Jour. Sci., XXIV., Nov. 1882, p. 362.

Slender pennatulids, with an axis through the whole length. Polyps arranged alternately, in a simple row, on each side. Calicles bilobed, appressed. Zoöids three to each polyp, one in front and one on each side of each cell. Spicula abundant in the calicles, rachis, and stalk; those in the stalk are small, oblong, triquetral, interwoven.

Distichoptilum gracile Verrill.

Amer. Jour. Sci., XXIV., Nov. 1882, p. 362, note.

Plate I. Figs. 1, 1 a, 1 b.

Long and slender, with a long stalk. Polyp-calicles rather large, rigid, closely appressed, with two sharp terminal lobes, filled with spicula, concealing the opening, and overlapping the base of the calicle in front. Zoöids small, not exsert, showing as small white spots at each side and in front of each calicle. Stalk long, slender, with a long narrow bulb. Color bright orange-red, due to the spicula; end of bulb yellowish.

Length, 18 inches, or 456 mm.; breadth in middle, 2 mm.; length of stalk, 100 mm.

The spicula of the calicles and rachis are long, triquetral, both oblong (Fig. 1 b, *c*) and fusiform, obtuse or acute at the ends, varying in slenderness; those of the stalk (Fig. 1 b, *d*) are much smaller, of the same general form, but mostly oblong, with obtuse ends.

A single perfect specimen of this curious species was taken by the U. S. Fish Commission, August 26, 1882, at Station 1123, in about 700 fathoms, S. E. of Nantucket Island, in N. Lat. 39° 59′ 45″, W. Long. 68° 54′.

Attached to this specimen was a fine example of *Astronyx Loveni*, which had the same bright orange-red color as the coral. In alcohol, however, this ophiuran rapidly lost its color, while that of the coral was not much altered.

GORGONACEA.

Family CERATOISIDÆ.

Keratoisidæ + *Acanelladæ* + *Mopseadæ* (*pars*) Gray, Cat. Lithophytes Brit. Mus., 1870, pp. 13, 16, 18.

Axis simple or variously branched, with long calcareous joints, which are often hollow, alternating with shorter horny joints. Branches, when present, sometimes arise from the calcareous joints, but more frequently from the horny ones. Base calcareous, usually divided into long, flat, irregular lobes, serving as anchors in the mud of the sea bottom. Cœnenchyma thin, commonly with long fusiform conspicuous spicula, sometimes with small scale-like ones at the surface. Calicles large and prominent, filled with large fusiform spicula, of which eight or more are larger than the rest and commonly project as sharp marginal spines between the bases of the tentacles, forming an armature for the protection of the incurved and imperfectly retracted tentacles.

This group bears about the same relation to *Isidæ* that *Muricea* does to *Plexaura* and *Eunicea* among the Gorgonians with a horny axis. In typical *Isis* the cœnenchyma is thick and filled with minute spicula, and the calicles are not prominent nor armed with spines.

Neither the mode of branching, nor the fact that the branches in some species arise from the horny, and in others from the calcareous joints, is a sufficient reason for separating the very closely allied genera here included into different families, as was done by Dr. J. E. Gray.

This family includes three well-marked genera that are found on our coast, viz. *Ceratoisis*, *Acanella*, and *Lepidisis*, nov. In addition to these, *Callisis* occurs in the Straits of Florida. The imperfectly known and not properly characterized genus, *Isidella* Gray, should probably be referred here, if it be recognized at all. These genera may be arranged as follows: —

A. *Branches arise from the calcareous joints.*

Ceratoisis. Cœnenchyma and calicles filled with large fusiform spicula. Calicles armed.

Callisis. Cœnenchyma with small oblong scales. Calcareous joints solid, or nearly so. Calicles with fusiform spicula, which do not form long marginal spines. Type, *C. flexibilis* V. (= *Isis flexibilis* Pourtalès).*

* *Callisis flexibilis* (Pourt. sp.). The type-specimen of this species has prominent, short cylindrical calicles, containing moderately large, rather short, blunt, oblong and fusiform, minutely warted spicula, not running the whole length of the calicles, and projecting very slightly, or not at all, beyond the margin. The cœnenchyma is thin, brown, filled with minute oblong or elliptical, flat, scale-like spicula, which also cover the surface of the calicles. The branches arise from near the proximal end of the calcareous joints, in the specimen examined. The calcareous joints, in the several broken branches examined on different specimens, were solid, or rarely had a very minute central tube.

AA. *Branches, if present, arise from the horny joints.*

Acanella. Cœnenchyma and calicles filled with large fusiform spicula. Calicles armed.

Lepidisis. Calicles filled with large fusiform spicula. Cœnenchyma with a layer of small oblong scales. Calicles armed.

Isidella (?). Cœnenchyma and calicles with fusiform spicula. Calicles unarmed (?).

Nearly all the known species of this group, including the largest and most luxuriant ones, are from comparatively deep water, and consequently require cold, or at least cool temperatures. Several species are arctic, or inhabit the deep fishing banks off the northern coasts of Europe and America, where they are bathed in the cold arctic currents. Some of the species are found at great depths (1,000 to 1,300 fathoms), where the temperature is very low. The group is well represented in the deep waters of the Caribbean Sea and Gulf of Mexico. At least nine species, belonging to the four principal genera, were taken in those waters by the "Blake" expeditions, 1877 to 1880. Among these there were certainly two, and perhaps three, of our northern species.

For the sake of comparison, I have added brief descriptions and a few figures of some of the West Indian forms of *Acanella* and *Lepidisis.*

Ceratoisis Wright.

Keratoisis Wright, Ann. and Mag. Nat. Hist., II., 1869, p. 427; III. p. 24.
Gray, Cat. Lith. Brit. Mus., 1870, p. 18.

In this genus the branches, which are usually few and distant, arise from the calcareous joints. Otherwise it agrees very closely with some of the sparingly branched species of *Acanella.* Indeed, it is difficult to determine to which genus some of the unbranched species should be referred. The calcareous joints are tubular. The calicles are strongly armed with large spiniform spicula, and the cœnenchyma also contains large fusiform spicula.

In this genus are included the largest known species of the family. Some specimens of *C. ornata* are more than four feet high. These are found at considerable depths, in cold water, off the coasts of Newfoundland and Nova Scotia.

Ceratoisis ornata Verrill.

Keratoisis ornata Verrill, Amer. Jour. Sci., XVI., 1878, pp. 212, 376.

Plate IV. Figs. 3 - 3 d.

Coral tall (sometimes over three feet high), distantly and irregularly branched, the branches spreading, often nearly at right angles, elongated, rather slender, gradually tapering, giving off, in the same manner, elongated branchlets. The branches and branchlets mostly arise from near the proximal

end of the calcareous joints, but sometimes from the middle. The calcareous joints are ivory-white, elongated, round, slightly enlarged at the ends, usually faintly and often indistinctly striated longitudinally, appearing smooth to the naked eye, but finely granulous under a lens; they are tubular, having a central tube equal to about a third or a fourth of their total diameter. Chitinous joints are usually golden yellow or bronze-color, sometimes plain brown, short, scarcely longer than thick in the larger branches, about twice as long as thick in the smaller ones, where they become translucent and brownish or amber-color, without the metallic lustre seen in those of the larger branches.

The calicles are usually, in dried specimens, prominent, elongated, somewhat expanding toward the end, and are crowded nearly equally over the whole surface; they are covered with large, conspicuous, acute spicula, which form, at summit, eight sharp projecting spinous points. The cœnenchyma is thin, translucent, yellowish, filled with long and large fusiform, conspicuous spicula.

A large specimen, well preserved in alcohol, from the Gloucester fisheries, lot 367, shows remarkable variations in the length and form of the calicles. Over most of the branches they are very long and prominent, constricted in the middle, with an expanded base and enlarged summit, crowned by eight prominent spines, surrounding the incurved and nearly retracted tentacles (Fig. 3 a). In this form of calicle the length is two to three times the average diameter. But on other branches the calicles are only prominent, subconical verrucæ, broadest at base, with the summit narrow, and the spines but little prominent (Fig. 3 b); these are often about as broad as high. Intermediate forms also occur on this specimen. The calicles are irregularly but rather uniformly scattered over the whole surface, and are mostly separated by spaces two or three times as great as their breadth, though some are in contact at their bases. The surface of the cœnenchyma and calicles in this example is covered with a soft integument, which nearly conceals the spicules, except at the border of the calicles; but they become conspicuous when dried. This example also has the basal part, which is deeply divided into irregular, palmate, flattened lobes, or root-like expansions, by means of which it anchors itself in the mud.

The large projecting spicula of the calicles are fusiform, usually more or less bent, and either acute at both ends or acute at the outer end and obtuse at the inner (Fig. 3 c, *e*); the surface is nearly smooth, or only slightly roughened in longitudinal lines on the basal part, or sometimes throughout, but in many cases the longitudinal lines of points become more evident on the inner end. They have a large yellowish brown nuclear portion. The larger of these measure 4.40 by .35, 4.10 by .33, 4.10 by .30, 3.90 by .25, 3.80 by .30, 3.70 by .22, 3.60 by .30, 3.00 by .30, 3.00 by .20 mm.

With these, below the margin, and in the polyps, there are many smaller and more slender, partly fusiform, partly oblong or rod-like spicula, with both ends similar, and either acute or obtuse, and usually distinctly but finely lined and roughened longitudinally and obliquely, especially near the ends,

which are often swollen, and as broad as the middle (Fig. 3 d, *f*, *g*). These measure 2.50 by .15, 2.30 by .20, 2.25 by .15, 2.22 by .13, 2.20 by .18, 2.20 by .15, 2.20 by .10, 2.10 by .10, 1.90 by .15, 1.80 by .15, 1.80 by .11 mm.

In the tentacles there are numerous smaller, oblong, or somewhat hour-glass-shaped spicula, of various sizes, mostly enlarged, obtuse and striated at both ends (Fig. 3 d, *h*, *i*). The larger of these measured .65 by .10, .45 by .06, .45 by .05, .30 by .03 mm.

The cœnenchyma contains large, scattered, fusiform spicula, finely striated longitudinally, and mostly acute at both ends, which are covered with small spiniform or conical warts, in rows. The larger of these measure 4.20 by .03, 4.10 by .025, 3.50 by .02, 3.50 by .018, 3.40 by .025, 3.20 by .02, 3.15 by .015, 2.80 by .02, 2.70 by .02, 2.65 by .015, 2.60 by .022, 2.40 by .02 mm. These large spicula are mostly nearly straight, but some are bent more or less. They are accompanied by a few much smaller fusiform spicula, acute at both ends, and by still smaller oblong ones, obtuse at the tips. These are from .015 to .023 mm. long, by about .004 to .005 mm. thick.

The largest specimen seen, which, however, lacks the base, was 1020 mm. (about 40 inches) in height; diameter of the main stem, not including calicles, 7 mm.; length of calicles, mostly 5 mm.; their diameter, about 2 mm.; length of calcareous joints of stem, about 50 to 70 mm.; of horny ones, 4 to 4.5 mm. One branch was 675 mm. (about 27 inches) long without dividing.

Height of one of the original specimens, 660 mm. (about 26 inches); breadth, 458 mm. (about 18 inches); length of longest undivided branchlets, 300 to 400 mm. (about 12 to 16 inches); diameter of calcareous joints of main stem (base absent), 9 mm.; of the larger branches, 5 mm.; length of the calcareous joints, in the larger branches, 30 to 48 mm., but mostly about 40 mm.; diameter in smaller branchlets, about 1.5 mm.; length, 19 to 32 mm.; length of chitinous joints of larger branches, 2.5 to 5 mm.

The two original specimens were taken, in 1877, by Mr. Philip Merchant, of the schooner "Marion," off Sable Island, N. S., in about 250 fathoms, and another was taken by Mr. George K. Allen, of the same vessel. Several other specimens have subsequently been obtained by other vessels of the Gloucester fishing fleet, from the banks off Nova Scotia, where it occurs in 200 to 300 fathoms. It was not taken by the Blake.

This is a large and beautiful species of a family formerly considered chiefly tropical in habitat, but now known to be peculiarly characteristic of rather deep water in all latitudes. The golden or bronzy chitinous joints usually contrast finely with the clear ivory-white calcareous joints.

The genus was founded by Professor E. Perceval Wright, in 1869, for a species (*C. Grayi* W.) very closely allied to this, and taken in deep water (400 fathoms) off the coast of Portugal.

A closely allied species, perhaps identical, was found in deep water in the Caribbean Sea by the Blake, in 1878–79; but the specimen is a fragment too imperfect to be readily identified.

Acanella Gray (emended).

Acanella Gray, Cat. Lithophytes Brit. Mus., 1870, p. 16.

Coral either simple or variously branched. Axis with long calcareous joints and very short horny ones. The branches, when they exist, arise from the horny joints, either singly or two or more together, sometimes forming whorls. Cœnenchyma very thin, containing, more or less abundantly, elongated fusiform spicula, usually of large size. Calicles large, elongated, composed of large, fusiform spicula, often obliquely arranged; the margin is armed by about eight long, spine-like, projecting acute spicula. Tentacles stiffened by abundant spicula. Base, in most cases, divided into large, flat, palmate lobes, which descend into the mud and serve as supporting roots or anchors.

This genus, as established by Gray, for *A. arbuscula* Johnson, had as one of its most prominent characters the verticillate arrangement of the branches. The discovery of several closely allied species without this peculiarity, one of them being entirely simple, shows that the mode of branching, as in most other genera of Gorgonacea, is only a specific character.

The relation of this genus to *Isidella* Gray is still doubtful, for the nature of the cœnenchyma and calicles of the type-species of the latter was unknown to Gray. Indeed, the precise species which he had in view is very doubtful, although he referred it to *I. elongata* Esper, a species that had never been properly described, and which could not be positively identified, as it was based on the axis only. The species described under the same name by Philippi is probably a distinct species, having elongated calicles, with long projecting spicula, as in *Acanella*.

I have hitherto referred to *I. elongata*, a species procured at Naples, many years ago, by Professor J. D. Dana, and of which several specimens, consisting of the axis alone, are in the Museum of Yale College. So far as the axis shows, these might belong either to *Acanella* or to *Lepidisis*, or to a genus distinct from either.

Koch has described a species, perhaps the same, under the name of *Isis Neapolitana*, which may be the species intended by Gray as the type of *Isidella*, and which is apparently the same as my *I. elongata* from Naples. In this species the calicles are not furnished with the projecting spicula, so conspicuous in *Acanella* and *Lepidisis*. The corresponding spicula are present, however, according to the figures given by Koch, as fusiform spicula, larger than the others, but not projecting beyond the margins of the elongated calicles. The cœnenchyma is thin, and contains small fusiform spicula. This species is, therefore, closely allied to *Acanella*, the principal difference being the less development of the marginal spines of the calicles. Possibly this may be the species called *Isidella elongata* by Gray, but it would be difficult to prove it. Therefore it might be best to reject the name, *Isidella*, as not recognizably established. Otherwise it might be restricted to such species as *I. Neapolitana* and *I. borealis* (= *Mopsea borealis* G. O. Sars), in which the marginal spines are not much developed and do not project.

Acanella Normani Verrill.

Acanella arbuscula Norman, Proc. Royal Soc. London, 1876, p. 210 (? *non* Johnson, 1862).

Acanella Normani Verrill, Amer. Jour. Sci., XVI., 1878, p. 212 (descr.); XXIII., 1882, p. 315.

Plate IV. Figs. 2, 2 a, 2 b.

This coral grows in symmetrical, thickly branched, bush-like forms, usually 6 to 10 inches high, and 6 to 8 inches broad. The base is calcareous, and divides into several large, divergent, irregularly palmate and digitate lobes or root-like branches, which serve to anchor and support the coral on the soft muddy bottoms which it usually inhabits; occasionally, however, the basal expansion attaches itself to pebbles, and in that case becomes incrusting, in part or wholly, according to the size of the pebble. The main central stem usually grows upright, in normal specimens, commonly with a short trunk, 25 to 50 mm. (1 to 2 inches) long, destitute of branches; above this the main branches are given off symmetrically, from the short horny joints, mostly in whorls of four at each of the joints, which are usually from 15 to 20 mm. apart. The branches are strongly divergent and spreading, and they give off from their horny joints similar whorls of branchlets, usually three or four to each joint; these are usually somewhat farther apart than those of the main stem, commonly 20 to 25 mm. The smaller branches are slender, with longer calcareous joints, and they give off slender branchlets from their horny joints, only one or two usually arising from a joint. The terminal branchlets are long, slender, divergent, with longer calcareous joints than the larger branches. The main stem and most of the larger branches are destitute of calicles, and along the smaller branches they are rather distantly and irregularly scattered, becoming more numerous, closer, and larger on the terminal branches, and especially toward their tips, where there is often a group of two or three, or more.

The calicles are long and prominent, divergent, and nearly rigid, owing to the large and long spines with which they are filled; they vary considerably in size and form, those at the tips of the branches (Fig. 2 a) being somewhat larger and better developed than most of those along their sides. These larger calicles are swollen at base, narrowed or subpedunculated just above the base, and then gradually enlarged toward the summit, where the margin is surrounded by eight long, slender spines, formed by the projecting ends of the large spicula; within the marginal spines the incurved tentacles are usually to be seen in alcoholic specimens. Below the margin the calicles are composed of numerous long, slender warted spicula, which vary considerably in size and form; those on the swollen basal portion are smaller, crowdedly imbricated, but do not project. The spicula are conspicuous in dried specimens, in which they are commonly less regular, and take oblique and more or less twisted positions. The calicles along the sides of the branches are irregularly ar-

ranged, and less regular in size and form than the terminal ones, but have the same structure; many of them agree closely in size with the terminal ones, and may be four to six times as long as broad; others are less than half as large; some stand very obliquely, but the larger ones usually diverge from the branch at a large angle, and then curve upward; they are obliquely seated upon the branchlets, with the bases swollen, and often larger than the branches which support them.

The cœnenchyma is thin and filled with long, slender, mostly fusiform or rod-shaped, finely warted spicula, which are not very numerous.

The spicula, both of the calicles and the cœnenchyma, are mostly long, slender, fusiform, often a little bent, and acute at one or both ends, minutely spinulated, and of various sizes. The largest, from the margins of the calicles, are usually smoother, more slender, and sharper at the outer or projecting end than at the other, which may be subacute or blunt, with the spinules more distinct and in rows (Fig. 2 b, *c*). Others are relatively stouter, regularly fusiform, with both ends alike, and either obtuse or acute; smaller ones (Fig. 2 b, *d*, *e*) of these forms occur, especially in the swollen basal portion.

Some of these various forms gave the following measurements: 3.10 by .14, 3.00 by .12, 2.90 by .12, 2.80 by .12, 2.60 by .09, 1.90 by .08, 1.80 by .08, 1.36 by .08, 1.30 by .07, 1.25 by .10, 1.04 by .06 mm.

Among the smaller forms (Fig. 2 b, *f*), many are slender, oblong, obtuse at both ends, and sometimes narrower in the middle. Some of these measured .36 by .06, .36 by .04, .23 by .03, .18 by .03 mm. Others are oblong or slightly fusiform, acute at both ends. Some of these measured .86 by .06, .86 by .04, .84 by .06, .80 by .06, .64 by .04 mm. The smallest (probably from the tentacles) are slender, oblong, mostly of nearly uniform diameter, or else a little larger at one end, obtuse or subacute, distinctly spinulated, most so in the middle or toward one end. Occasionally large, compound, cross-shaped spicula occur.

Color of stem, branches, and calicles, in life, light salmon to orange; tentacles translucent, whitish, stiffened by white spicules. In alcohol the color is not much changed. When dried the color usually becomes darker orange, or orange-brown.

This is an abundant species all along our coast, from off Chesapeake Bay to Newfoundland, at considerable depths.

It was taken by the Blake, in 1880, at a number of stations along the Gulf Stream Slope, from off George's Bank to the region south of Long Island, in 260 to 1,242 fathoms.

It has been dredged and trawled in great abundance by the U. S. Fish Commission, at many stations, in 219 to 640 fathoms, along the Gulf Stream Slope, from off Nantucket and Martha's Vineyard to the region off Chesapeake Bay, in 1880, 1881, and 1882. It was particularly abundant at Station 881, in 325 fathoms; Station 893, in 372 fathoms; Station 938, in 317 fathoms; Station 947, in 312 fathoms; Station 1029, in 319 fathoms.

It has also been brought, in considerable numbers and in many lots, from

the deep fishing grounds off Newfoundland and Nova Scotia, by the Gloucester halibut fishermen. Off Greenland, "Valorous" Expedition, — Norman.

The following specimens were dredged by the Blake, in 1880.

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
306	524	41° 32′ 50″	65° 55′	5 in bad state.
307	980	41° 29′ 45″	65° 47′ 10″	4, with fragments.
308	1242	41° 24′ 45″	65° 35′ 30″	7 in bad state.
309	304	40° 11′ 40″	68° 22′	13
310	260	39° 59′ 16″	70° 18′ 30″	Sev. fragments.
312	466	39° 50′ 45″	70° 11′	12 in bad state.
339	1186	38° 16′ 45″	73° 10′ 30″	1, with fragments.

This species is closely allied to the *Acanella arbuscula* (Johnson) Gray, described from off Madeira, in 1862. It may, in fact, ultimately prove identical when the specimens can be directly compared. The figure of *A. arbuscula* indicates a more diffusely branched form, with more slender branches and branchlets. The calicles, also, judging from the figure, are different in form, but this might be largely due to distortion in drying. The Arctic form described by Norman under this name is evidently identical with our species, but the use of the same name was, apparently, accidental, as he did not refer to Johnson's species.

From the Bay of Yeddo, Japan, I have several specimens of an *Acanella* without the cœnenchyma, which I cannot distinguish by the axis alone from *A. Normani.* They were collected by Professor E. S. Morse.

Acanella eburnea (Pourtales) Verrill.

Mopsea eburnea Pourtales, Bull. Mus. Comp. Zoöl., I., 1868, p. 132.

Plate IV. Fig. 5.

Loosely and not very abundantly branched, the branches arising from the horny joints, sometimes singly, sometimes two or three from one joint, but not forming whorls in any of the specimens examined. The branches are often crooked, slender; and usually spread widely at the base. The calcareous joints are long, slender, translucent white, distinctly grooved, and solid, in both the larger and smaller branches examined; the horny ones are short, dark brown or brownish yellow. The calicles are decidedly swollen at the base, and usually broader than the small branches on which they are obliquely set; they usually taper distally, and the slightly expanded margin is armed with eight large, sharp, spinous spicula, which are minutely warted or spinulated over the whole surface. Below the margin the calicles are covered with numerous and crowded, much smaller, slender, finely warted spicula, which are arranged obliquely or somewhat spirally below the middle. The cœnenchyma is very thin; near the calicles, and especially near the ends of the branches, the

spicula are much like those of the lower part of the calicles, but elsewhere they are smaller oblong forms, blunt at both ends. The terminal calicles on the outer branchlets are the largest and most prominent; those on the sides of the larger branches are shorter, oblique, and verruciform, with swollen bases.

The following specimens were dredged by the Blake, 1877–80.

Station.	Fathoms.	Locality.	Specimens.
1877–78.			
29	955	N. Lat. 24° 36′, W. Long. 84° 5′	1
1878–79.			
256	370	Off Grenada	1
1880.			
V.	288	Off Santiago	1
VII.	610	N. Lat. 17° 28′ 30″, W. Long. 77° 30′	1
XVIII.	600	" 18° 20′ 30″, " 87° 16′ 40″	3

Acanella spiculosa Verrill, sp. nov.

Mode of branching unknown, except that the branches originate from the horny joints. Axis in the branches very slender; calcareous joints long, solid, white; horny joints very short, orange-yellow. Cœnenchyma composed of numerous large, more or less crooked, fusiform spicula. Calicles elongated, more or less cylindrical, usually somewhat enlarged at the summit and slightly swollen at the base; summit armed with eight large, rather stout, sharp, projecting spicula; sides of the calicles covered with similar large, fusiform spicula, mostly somewhat obliquely placed, and curved to correspond to the surface of the calicles; those at the bases of the calicles are usually larger and very crooked, intermingled with some of smaller size.

Length of the larger calicles, from 3.5 to 4.5 mm.; diameter, 1.25 mm.

Only a single specimen of this species has been seen, consisting of two small branches, one of which gives rise to a single small, lateral branchlet. It closely resembles *A. eburnea*, but is distinguished by the very much larger size of the spicula in the basal part of the calicles, and in the cœnenchyma.

Station 222, in 422 fathoms, off St. Lucia, Blake Expedition, 1878–79.

Acanella simplex Verrill, sp. nov.

Rather slender, apparently unbranched. Calcareous joints long, slender, distinctly sulcated, solid (in the several joints examined); horny joints short, dark brown.

Calicles numerous, prominent, rather long, cylindrical or enlarged distally, covered with stout, often curved, blunt or not very acute, finely warted, oblong or fusiform spicula, and armed at the margin by eight similar spicula of somewhat more elongated form, but less acute than in most other species. The base is supported by similar large, often much curved spicula. Similar large, fusiform spicula extend a little beyond the base of the calicles, in the thin cœnenchyma, becoming smaller away from the calicles; the cœnenchyma is

often largely destitute of spicula between the calicles when rubbed; in many parts only a few scattered, small, oblong and fusiform, blunt, warted spicula are found, here and there, but in other places it is covered with smaller and larger oblong spicula, intermingled. Color in alcohol, yellowish brown.

Height of the largest example, 230 mm.; length of calicles, 5 mm.; diameter, 1.5 to 2 mm.; diameter of axis, 1 mm.

The following specimens were dredged by the Blake, 1878–80.

Station.	Fathoms.	Locality.	Specimens.
205	334	Off Martinique	1
288	399	Off Barbados	1

A specimen was also dredged by Mr. Pourtales, on the "Bache," March 4, 1869, first haul, in 450 fathoms.

Lepidisis Verrill, gen. nov.

Axis with long, tubular, calcareous joints alternating with short horny ones; simple or branched, the branches, when present, arising from the horny joints. Base divided into long, irregular, flat lobes. Cœnenchyma thin, with an external layer of small, oblong, scale-like spicula, sometimes with a few fusiform spicula beneath them, especially around the calicles.

The calicles are large and elongated; the margin is armed by about eight long, spiniform, projecting spicula, alternating with the tentacles; their sides are filled with large, fusiform spicula, which are more or less covered externally by small, oblong, scale-like ones, like those of the cœnenchyma. Tentacles filled with numerous, small, oblong, blunt spicula.

This genus is closely allied to *Acanella*, differing only in having the external layer of small scale-like spicula, both in the cœnenchyma and on the calicles.

Lepidisis caryophyllia Verrill, sp. nov.

Plate IV. Figs. 1, 1 a, 1 b, 1 c.

Two specimens are in the collection of 1880, both unbranched, but both are broken. One (see Plate IV. fig. 1), from Station 308, has the basal processes. The other, which is incomplete at both ends, is a simple stem over a foot (160 mm.) long, and about 1.5 to 2 mm. in diameter. The white calcareous joints, except near the base, are long (45 to 55 mm.) and hollow; the brown horny joints are short (1 to 2 mm.); the cœnenchyma is very thin, filled with small, oblong, blunt, flat or scale-like spicula, with some longer fusiform ones around the calicles, and a few scattered ones of the same kind. The calicles are few, distant, long (6 to 8 mm.), clavate, slender at base, enlarging toward the summit, which is expanded at the end (2.5 mm.), and armed usually with eight long and large spine-like or fusiform spicula, which project in a circle around the margin, and run back nearly the whole length of the calicles. These are intermixed with and surrounded by numerous smaller and more

slender ones. The calcareous joints are rather strongly sulcated, especially toward the base, and have a rather large central cavity. The base is divided into root-like, irregular, flattened, crooked anchoring-lobes, much as in *Acanella Normani* and many other forms which inhabit soft muddy bottoms in deep water.

The spicula of the calicles are of several forms and of very diverse sizes. The largest (Fig. 1 b′, *d*, *e*) are long, often a little bent, rather slender spines, slightly thicker near the middle, with the inner end flattened and obtuse, and the outer end acute and nearly smooth toward the tip ; elsewhere the surface is covered with minute conical spinules, which are arranged in divergent, longitudinal rows, more conspicuous near the inner or obtuse end (Fig. 1 b). These large spicula vary much in size. Some of them measured 5.50 by .13, 5.10 by .25, 4.25 by .11, 3.75 by 10, 3.42 by .13, 3.25 by .15 mm.

With these are others, of smaller size and usually more slender, which are flattened, obtuse, and spinulated at both ends, or throughout; some of these are broader at the ends than in the middle, while others are of nearly uniform breadth; they are straight, or but little bent; and some are very slender; they vary greatly in size. Some of these measured 3.68 by .10, 2.00 by .06, 1.75 by .075, 1.10 by .08 mm. A few are slender and pointed at both ends; one of these was 2.50 by .05 mm.

There are also, from the polyps, some smaller, minutely spinulated, fusiform spicula (Fig. 1 b, *f*), acute at both ends (perhaps from the tentacles); and still smaller flattened, oblong spicula, obtuse and often enlarged at both ends, and longitudinally striated (Fig. 1 b, *g*, *h*, *i*). The latter come from the tentacles. The cœnenchyma is filled with small, oblong, flattened spicula (Fig. 1 c), which are often narrower in the middle than near the ends, which are obtusely rounded; the surface is finely striated or grooved and roughened longitudinally. Some of these measured .16 by .004, .16 by .003, .13 by .004, .13 by .003 mm. Around the calicles, and occasionally elsewhere, long, spiniform spicula, like the medium-sized ones of the calicles, are mixed with those characteristic of the cœnenchyma.

The following specimens were dredged by the Blake, 1878–80.

Station.	Fathoms.	Locality.	Specimens.
1878–79.			
161	583	Off Guadeloupe	1 broken.
1880.			
308	1242	N. Lat. 41° 24′ 45″, W. Long. 65° 35′ 30″	1 "
339	603	" 34° 39′ 40″, " 75° 14′ 40″	1 "

Lepidisis longiflora Verrill, sp. nov.

Plate IV. Figs. 4, 4 a.

A large and stout species, sparingly and distantly branched, the branches arising from the horny joints singly, or two at a time, and in that case usually opposite; the branches are ascending, usually straight or a little curved. The

calcareous joints of the branches are rather long and moderately slender, swollen at the ends, distinctly and often strongly sulcated; they usually have a rather large central tube. Horny joints very short, brown. Calicles large, long, cylindrical or nearly so, often enlarged distally; the margin is armed with eight large, stout, spinous spicula, not projecting very far, the free part nearly smooth; below the margin the sides are supported by large fusiform spicula, somewhat obliquely placed, and the exterior is covered almost entirely by small, oblong, flat, scale-like spicula, blunt at the ends and often narrowed in the middle; their length is about three times their breadth (Plate IV. Fig. 4a, *b*, *c*).

The thin cœnenchyma is also composed mainly of these same scale-like forms, which entirely cover its surface in dry specimens. Some of these measured .46 by .13, .33 by .10, .30 by .11, .30 by .10, .28 by .09, .25 by .10, .25 by .09, .23 by .10, .20 by .07, .18 by .07, .18 by .06 mm. They are minutely roughened by longitudinal lines which diverge toward the ends, where the edges are finely denticulated or serrate; many of them are also denticulate along the sides.

The following specimens were dredged by the Blake, 1877–79.

Station.	Fathoms.	Locality.	Specimens.
1877.			
2	805	Off Morro Light	1
1878–79.			
131	580	" Santa Cruz	1
190	542	" Dominica	1
266	461	" Grenada	1

Lepidisis vitrea Verrill, sp. nov.

Mode of branching unknown. Axis slender; calcareous joints translucent, strongly fluted, and with a very large central tube, so large that the solid matter is reduced to a thin, fragile shell; horny joints short, pale yellow. Cœnenchyma very thin, with few, scattered, small, oblong or hour-glass-shaped spicula, and some fusiform ones. Calicles very much elongated, narrowed toward the base and expanded at the summit, which is armed with eight very sharp, much elongated, nearly smooth, glassy, fusiform spicula, which extend along the sides of the calicles nearly to the base. Other similar acute, fusiform spicula, mostly of smaller size, and only slightly roughened, cover the sides of the calicles; these are mostly straight and often extend the whole length of the calicles; with these are long, slender, oblong spicula, with both ends blunt.

Of this species only two fragments, without branches, have been seen. It is remarkable for the large size of the central tube of the axis, and also for the unusually long and sharp spicula that surround the summit of the calicles, as well as for the translucent and glassy appearance of both the spicula and axis. In the form of the calicles it most resembles *Lepidisis caryophyllia*.

Station 222, in 422 fathoms, off St. Lucia, Blake Expedition, 1878–79.

Family CHRYSOGORGIDÆ Verrill, nov.

Coral variously branched, the branches most commonly taking a spiral arrangement. Axis partially calcareous, generally with a brilliant iridescence and metallic lustre. Base, in most of the species where it has been observed, calcareous, and divided into irregular, divergent, root-like processes for anchoring in the mud, but in some species it is flattened and adherent to pebbles. Usually the hard, white calcareous base is sharply contrasted with the axis of the stem. The calicles are prominent, scattered along the branches, either standing at right angles or obliquely; they are covered with moderately large elongated or flat spicula, and are usually eight-lobed at the summit. Cœnenchyma very thin, with oblong or elongated spicula.

This family includes some of the most beautiful and interesting of all the known Gorgonians. These species are remarkable both for the elegance of the forms in which they grow, and for the brilliant lustre and opaline and iridescent colors of the axis, which in some species has the bright emerald-green lustre of the most brilliant tropical beetles, and in others is like burnished gold or polished mother-of-pearl.

The known species are all inhabitants of deep water, and all are from the West Indian seas, except *Dasygorgia Agassizii*, which occurs off the New England coast. The observed species can be referred to the following genera.

A. *Much branched, often spirally; the branches repeatedly forking.*

Chrysogorgia. Calicles elongated, often narrowed near the base, covered with rather long rough spicula, which are more or less transverse over the basal half, and curved to fit the surface. Spicula of the cœnenchyma elongated or fusiform, warted.

Dasygorgia. Calicles obliquely placed on the branches, swollen at base, covered with flat, oblong spicula, which are arranged longitudinally or obliquely. Spicula of the cœnenchyma oblong or scale-like, nearly smooth.

AA. *Axis forming a spiral or helix, with slender undivided branches, in a single spiral row.*

Iridogorgia. Calicles verruciform, with swollen bases extending along the branches, filled with slender elongated spicula, obliquely and transversely arranged. Spicula of the cœnenchyma similar. Surface of cœnenchyma with peculiar soft verrucæ.

Although but one species (*Dasygorgia Agassizii*) has been found on our coast north of Florida, I have included here some of the West Indian forms for the sake of comparison, and more fully to illustrate the characters of this hitherto imperfectly known group.

This family is related, in several respects, to Primnoidæ, especially to *Calligorgia* and allied genera, which are likewise chiefly found in deep water, and some of which have the axis similar in structure and lustre. In the latter group, however, the calicles are differently constructed, and the spicula be-

come genuine scales. The sharp distinction between the calcareous base and the more horny stem, above, indicates, perhaps, some relationship with the Isidæ.

Dasygorgia Agassizii Verrill, sp. nov.

Plate II. Figs. 4, 4 a, 4 b.

Two specimens of this elegant species were taken off George's Bank, at Station 308, in 1,242 fathoms, N. Lat. 41° 24′ 45″, W. Long. 65° 35′ 30″.

The larger specimen, broken at both ends, is about 225 mm. high; the stem is about 2.5 mm. in diameter at base, while the slender side branchlets are 40 to 60 mm. long, and exceedingly slender and hair-like. Toward the base there were a few larger branches, only one of which remains. Along the main stem, which is a little bent in zigzag, the side branchlets are numerous and close, and spread nearly at right angles, ascending a little at their bases; they are arranged somewhat alternately, but form five rows along the stem, or, in other words, every sixth one lies in nearly the same vertical plane; the vertical distance between successive branches is about 2 mm., and between every sixth, in the same line, from 10 to 12 mm.

The branchlets are two or three times forked; the first fork is 3 to 4 mm. from the axil; each branch usually again divides 3 to 5 mm. from the first forking; after this the forking is unequal, some of the divisions remaining simple, others dividing; the ultimate branchlets are exceeding delicate and hair-like, and have a tendency to lie in horizontal planes. The axis of the main stem is round, not grooved, smooth and lustrous, with a bright, bronze-like lustre and light yellow color; that of the branchlets is pale amber-color, and translucent; the axis is largely horny, and can be easily cut with a knife, but it effervesces in acids. At the base the nature and color of the axis abruptly change, the basal expansion and root-like processes being ivory-white and stony. In our examples the base divides into several long, divergent, irregular, palmate, flattened processes, for anchoring the coral in the mud.

The calicles are few, prominent, oblique, rather distantly scattered along the sides of the branchlets, which they often exceed in diameter; they are mostly obliquely set, their summits being directed upward and outward, while the basal portion is larger, swollen, and more horizontal along the branchlets; the summit is conspicuously eight-lobed, and the tentacles are not entirely retractile, their bases showing as eight convergent, spiculose lobes; the sides of the calicles are covered with slender, oblong, flat spicula, which are mostly parallel with the calicle on the lower half, but near the bases of the tentacles become more or less oblique.

The spicula of the calicles (Fig. 4 b, *c*, *d*) are mostly small, flattened, slender, oblong, often with nearly parallel sides, but mostly narrower in the middle, bluntly rounded at the ends, the surfarce finely striated; some of these measured .18 by .05, .16 by .05, .16 by .04, .15 by .05, .13 by .04 mm. Toward the apex of the calicles and in the bases of the tentacles, there are many acute

or obtuse fusiform spicula, often twice as long as the preceding, and equalling or exceeding them in breadth, and with the surface minutely spinulated. Some of these measured .34 by .04, .33 by .045, .32 by .04, .30 by .035, .25 by .03 mm.

The cœnenchyma is very thin and delicate, filled with minute, flat, oblong, obtuse spicula (Fig. 4 b, *e*), in form much like the first or commonest kind from the calicles, described above, but rather smaller.

The color of the calicles and cœnenchyma is pure white in alcohol.

Dasygorgia elegans Verrill, sp. nov.

This species is closely allied to the preceding.

Coral tall, round, symmetrical, elegantly spirally branched, with the main stem bent in zigzag, and the branches arranged nearly as in *D. Agassizii*, but closer, shorter, and more numerously subdivided. The branchlets are shorter and less flexible, those from each branch are situated nearly in the same horizontal plane. The base consists of several rather long, divergent and descending, clear white, calcareous, more or less crooked, root-like lobes, some of which are forked. The axis of the main stem is light brownish yellow, and but little iridescent; that of the branchlets is pale yellowish white with slight iridescence.

The calicles are larger and stouter than in *D. Agassizii*, and set more nearly perpendicular to the branches. They are swollen at the base and summit, and terminate in eight distinct spiculose lobes. The sides are covered with stout, oblong, rather irregular, blunt, finely spinulated or warted spicula, which are decidedly larger, stouter, rougher, and less numerous than in *D. Agassizii*. The thin cœnenchyma is filled with smaller, oblong, finely spinulated spicula, larger and rougher than those of *D. Agassizii*.

Height, 160 mm.; breadth in middle, 45 mm.

Station 283, in 237 fathoms, off Barbados, 1878–79.

The following specimens were dredged by the Blake, 1878–79.

Station.	Fathoms.	Locality.	Specimens.
260	291	Off Grenada	1
283	237	" Barbados	2 typical.
284	347	" "	3 "

Dasygorgia spiculosa Verrill, sp. nov.

Plate II. Fig. 5.

Coral larger and stouter, but spirally branched, as in the two preceding species. The branches are larger and longer, with fewer and less regular branchlets than in *D. elegans*, and they do not lie in horizontal planes; they diverge widely, at the successive forkings, and in different planes; the terminal ones are very slender. The main stem is rather stout and bent in zigzag at the origin of the branches; it is light brownish yellow, with little iridescence.

The base, which is present in one example, is calcareous, and spreads out widely and irregularly over a fragment of dead coral. The calicles are larger than in either of the two preceding species; they mostly stand at nearly right angles to the branches, but those near the tips are oblique; they are constricted somewhat above the swollen base, but enlarged and eight-lobed at the summit. The sides of the calicles are covered with unusually large, fusiform and oblong, finely warted spicula, longitudinally and obliquely arranged; at their bases, and in the cœnenchyma near their bases, are longer and thicker fusiform spicula, usually acute and finely warted or spinulated; near and around the bases of the terminal calicles (Fig. 5) these often become remarkably large. The cœnenchyma elsewhere on the branches is filled with much elongated, slender, acute, fusiform spicula of the same character, but smaller; on the main stem, near the base, they are much smaller, short, oblong, blunt, and roughly warted.

Height, 210 mm.; breadth, 60 mm.

The following specimens were dredged by the Blake, 1877–79.

Station.	Fathoms.	Locality.	Specimens.
1877–78.			
44	539	N. Lat. 25° 33′, W. Long. 84° 35′	3 good, with bases.
1878–79.			
190	542	Off Dominica	1 and fragments.
195	502½	" Martinique	3 typical.
205	334	" "	1 "
222	422	" St. Lucia	Fragments.
227	573	" St. Vincent	1

Dasygorgia squamata Verrill, sp. nov.

Coral spirally branched, nearly as in the preceding species, with which it agrees nearly in size and appearance.

The axis is yellowish or amber-colored, with a pale iridescence. The calicles are large, about the same in size and shape as those of *D. squamosa*, and mostly stand nearly at right angles to the branch. They are decidedly enlarged at the summit, and are unusually smooth, owing to the nature of the spicula, which are rather large, flat and smooth, scale-like, oval, oblong, or irregular in shape, and so closely imbricated and fitted together as to resemble a coat of mail, giving the surface of the calicles a smooth appearance under the microscope; these flat spicula are iridescent; near the summit and on the eight lobes, at the bases of the tentacles the spicula become smaller, narrower, and oblong. The cœnenchyma is filled with smaller, smoothish, flat, oblong and irregular, scale-like spicula, which become larger and more scale-like near the calicles.

The following specimens were dredged by the Blake, 1878–79.

Station.	Fathoms.	Locality.	Specimens.
227	573	Off St. Vincent	1
283	237	" Barbados	2

Dasygorgia splendens Verrill, sp. nov.

Coral slender, spirally branched, much as in *D. spiculosa* and *D. Agassizii*, but it apparently has a lower and more bushy growth. Main stem rather stout, bent in zigzag ; distance between branches usually 5 to 8 mm. Axis polished, with a very brilliant metallic iridescence, in which deep emerald-green and blue tints predominate ; in the branches the axis is amber-colored, with less iridescence. Cœnenchyma thin, with small fusiform spicula. The calicles are distant, rather stouter than in most species of the genus, but perhaps a little shorter than in *D. spiculosa;* they mostly stand a little obliquely ascending on the branches, and are much broader than the smaller ones; they are nearly cylindrical, or only a little constricted above the base, which is a little expanded; summit prominently eight-lobed. The calicles are thickly covered with rather large, oblong, blunt, thickened, smoothish, iridescent spicula, which rise up distinctly above the surface and are not closely imbricated; they lie nearly longitudinally on the sides, but obliquely at the base, where the largest ones are situated. The spicula of the cœnenchyma are smaller, flattened, oblong and fusiform, often with indented edges, but with a smooth, lustrous, iridescent surface.

Off Santa Cruz, Stations 124 and 131, in 580 fathoms, Blake Expedition, 1878–79.

Chrysogorgia Desbonni Duch. & Mich.

Duchassaing & Michelotti, Supplément Mém. Corall. des Antilles, pp. 13, 21, pl. 1, figs. 7, 8, pl. 4, fig. 5.

Plate II. Figs. 6, 6 a, 6 b.

Coral flabellate, sometimes with the branches all in one plane, in other cases dividing near the base into two or more principal branches, which stand parallel and take a fan-shaped form. The main branches divide repeatedly into smaller branches by successively forking. The branchlets are divergent, and the forks are from 3 to 6 mm. apart. The terminal branchlets are small, short, and somewhat rigid. The axis is rather hard, rigid, somewhat calcareous, in the main stem and larger branches dark brown or brownish black, in the smaller branchlets yellowish brown, translucent. Cœnenchyma thin, white in alcholic specimens, and composed of irregular, oblong and fusiform, roughly warted spicula (Figs. 6 a, 6 b). Calicles scattered, often secund, prominent, more or less enlarged at the summit; they stand at right angles to the branches, or even turn somewhat downward. The calicles (Fig. 6) are covered with rather large, elongated, roughly warted, curved spicula, arranged transversely, the curvature of the spicula corresponding to the surface of the calicles; summit of the calicles strongly eight-lobed, the lobes corresponding to the bases of the tentacles, and filled with smaller spicula.

Height of ordinary specimens, 65 to 80 mm.; breadth, 60 to 70 mm.

Taken at numerous localities in the Caribbean Sea and among the Antilles, in 88 to 163 fathoms, by the Blake, in 1878–79, and off Cuba, in 288 fathoms, in 1880.

Chrysogorgia Fewkesii Verrill, sp. nov.

Chrysogorgia Desbonni Pourtalès, 1868 (*non* Duch. & Mich.).

Coral tall, spirally branched, nearly as in *Dasygorgia Agassizii* and *D. spiculosa*, but larger and stouter, with thicker and more numerously divided branches; stem strongly bent in zigzag ; the main branches diverge, on all sides, nearly at right angles, one arising from the outer side of each angle; distance between the branches from 4 to 6 mm. The branches fork repeatedly, the first division being usually about 10 to 12 mm. from the main stem; subsequent divisions are at unequal distances, the final branchlets numerous, very small, and spreading widely. Axis smooth, hard, brownish yellow or amber-colored in the stem and larger branches, and with only a slight iridescence; pale yellow, translucent, very slender, in the smaller branches. Cœnenchyma thin, white in alcoholic specimens, composed of large, fusiform, warty spicula, arranged lengthwise of the branches. Calicles irregularly scattered, rather small, prominent, usually constricted below the middle, with the summit and base enlarged; they mostly stand nearly at right angles to the branches, those near the tips obliquely ascending. Surface of the calicles covered with large, stout, warty, curved spicula, which are arranged obliquely and transversely toward the base, and mostly transversely in the middle portion ; summit of the calicles strongly eight-lobed, the lobes filled with smaller, stout, blunt spicula. Height of one of the largest examples, 170 mm.; breadth, 110 mm.

Station 227, in 573 fathoms, off St. Vincent, W. I., Blake Expedition, 1878–79. Several specimens. Also from several other localities in the same region, and off Cuba.

This species is dedicated to Mr. J. W. Fewkes, of the Museum of Comparative Zoölogy.

Iridogorgia Verrill, gen. nov.

Axis partially calcareous, with a brilliant iridescence; in the only known species it grows in the form of an upright spiral, or helix, from which a single series of long, slender, simple branches is given off on the outer side, so that they likewise have a spiral arrangement.

Calicles scattered along the branchlets, far apart, verruciform, with a swollen base, elongated in the direction of the branch, filled with slender fusiform spicula. Tentacles large, not retracted in the alcoholic examples, and not stiffened by spicula. Cœnenchyma very thin on the branchlets, containing slender fusiform spicula; on the stem and basal portion of the branches covered with

small, prominent, rounded, soft verrucæ, having the outer surface composed of a layer of special nettling cells; these verrucæ also extend over the basal part of the lower calicles. They may, perhaps, be of the same nature as the zoöids of Pennatulacea.

Iridogorgia Pourtalesii Verrill, sp. nov.

Plate II. Figs. 7, 7 a.

Main stem strong, rather rigid, calcareous, growing in a remarkably regular, open, upright spiral or helix. Base not obtained. Branches numerous, long, slender, delicately tapered, flexible, undivided; they arise very regularly, at intervals of about 4 to 6 mm., in a single row, along the side of the main stem that forms the outside of the spiral, and spread out laterally and widely, nearly at right angles to the stem, so that the whole coral has a broad spiral form, something like the skeleton of a spiral staircase.

The axis, in our example, makes about five volutions; its apex becomes slender and acute, but the lower end is incomplete.

The cœnenchyma is thin, and filled with slender fusiform spicula beneath the surface, which is soft, and bears numerous minute, rounded, elevated, soft verrucæ, which cover the main stem and proximal part of the branches, extending also over the basal portion of their proximal calicles, but they gradually become smaller and disappear farther out on the branches.

Calicles are not found on the main stem, except rarely one close to the origin of a branch; on the branches they are placed singly, and rather far apart, along the upper side; the distance between them is usually from 5 to 10 mm. The calicles are mostly broader than the branches on which they are situated; they have a swollen basal part, extending somewhat along the branch; the upper part is verruciform, and is usually surmounted by the large, incurved tentacles, which do not appear to be capable of entire retraction. The proximal calicles (Fig. 7) are the largest, and have very large tentacles, with swollen translucent stems, in which there are only a few slender spicula, close to the base; the pinnæ are elongated, slender, and without spicula. The calicles are filled with slender, nearly smooth, acute spicula, oblique and transverse in the basal portion, but becoming longitudial at the summit, between the bases of the tentacles.

In alcohol, the color of the calicles, tentacles, and cœnenchyma is white; the denuded axis and branches have a bright golden or pale bronze-like lustre, and reflect brilliant iridescent colors, in which light green and golden yellow predominate; by transmitted light the axis of the branches is pale wax-yellow and light amber.

Height of main stem, 200 mm.; diameter at lower end, about 2 mm.; diameter of larger branches, at base, 1 mm. or less. The larger, upright, fusiform spicula in the distal part of the calicles measure .56 by .04, .48 by .04, .46 by .05, .42 by .04 mm.; those of the basal part of the calicles, .55 by .05, .55 by .04, .52 by .05, .50 by .04, .42 by .035, .42 by .025, .28 by .03,

.28 by .02, .24 by .03, .18 by .02 mm.; those of the cœnenchyma, .50 by .02, .38 by .015, .22 by .015 mm.

Station 190, in 542 fathoms, off Dominica, and Station 173, in 734 fathoms, off Guadeloupe, 1878–79, Blake Expedition.

Family PRIMNOIDÆ (emended).

Primnoadæ (*pars*) GRAY, Proc. Zoöl. Soc. London, 1857, p. 285; 1859, p. 483.
Primnoidæ (*pars*) VERRILL, Revision Polyps E. Coast N. Am., in Mem. Bost. Soc. Nat. Hist., I., 1864, p. 8; Trans. Conn. Acad., I., 1869, p. 418.
Primnoadæ (*pars*) + *Calyptrophoradæ* + *Calligorgiadæ* (*pars*) GRAY, Cat. Lithophytes Brit. Mus., 1870.
Primnoadæ (subfamily) STUDER, Monatsb. Akad. Berlin, for 1878, p. 641, 1879.

This family should, properly, be separated from *Muriceidæ*, and restricted so as to include only those genera in which the spicula of the cœnenchyma and calicles are scale-like and the axis more or less calcareous, at least in the main stem. The calicles are usually elongated and pedunculated, or narrower at base than at summit; they are frequently closed at the summit by eight opercular scales. In most of the species the calicles are arranged in whorls, which are often closely crowded, but in some cases they are in two simple, alternating rows. The *Muriceidæ* differ in having the axis entirely horny, and in having large fusiform or spiniform spicula. Gray erroneously included in his Primnoadæ *Swiftia* and *Thesea*, which have the axis horny and the spicula not scale-like; *Riisea*, which is closely allied to *Verrucella* and *Gorgonella;* and *Chrysogorgia*, the type of a distinct family. In his *Calligorgiadæ* he erroneously included *Scirpearia*, *Nicella*, and *Raynerella*, which are closely allied to *Verrucella.* There is no good reason for separating the three groups named by him.

Primnoa Pourtalesii VERRILL, sp. nov.

Plate II. Figs. 2, 2 a - 2 c.

The coral is plumose, with regularly pinnate branchlets, all in one plane. Near the base there are several divergent branches, like the main stem. The stem is compressed in the same plane with the branches, and is a little bent in zigzag between the branchlets. The branchlets are very regular, slender, straight and nearly parallel, alternating on the two sides, and diverging at an angle of about 45° from the stem. They bear the calicles in two close, regular, alternating rows. The calicles are elongated, expanded at the summit, and curve a little upward and forward, so that the openings all face the front side of the coral; they are elegantly clad in a covering of small imbricated scales, forming several rows, and the aperture is closed by eight regular, convergent, triangular scales. Along each side of the main branches there is also a row of similar calicles, usually two on each side, between the bases of successive branchlets.

A very small specimen, 24 mm. high, attached to a pebble, has a small conical base; it has already given off four small, unequal branches; the calicles are like those of the more mature examples, but smaller.

The color, in alcoholic specimens, is white; axis light yellow.

The largest specimen, without its base, is 120 mm. high, 75 mm. broad.

The scales of the calicles (Figs. 2 b, 2 c) are thin and of various forms, roundish, oval, or more or less angular, usually with finely serrate margins; they have a prominent nuclear point, near the proximal edge, from which structural lines radiate; the outer surface is covered with small, prominent, unequal, sharp warts and spinules, sometimes taking the form of thin, elevated, radial crests; the spinules are crowded in the central area, becoming more scattered toward the distal margin; they usually appear to be irregularly arranged, but radial rows can often be distinguished. Some of these scales measured .31 by .28, .30 by .18, .29 by .25, .25 by .22 mm. The opercular scales (Fig. 2 d) have the form of an isosceles triangle, with the distal end acute and the basal angles rounded; the raised nuclear point is near the broader end, and from it rows of warts, spinules, and small crests run, radially, toward the margins, but usually leave the distal and somewhat of the lateral edges bare; the spinules are largest on the distal rows, and are strongly inclined toward that end of the scale; the margins are finely serrulate. Two of them measured .34 by .20, and .33 by .16 mm. The scales of the cœnenchyma (Fig. 2 e) are similar to the lateral scales of the calicles, but smaller and more rounded, with a more central nucleus. They vary considerably in size and form, and are mostly covered with rough, unequal warts and spinules, arranged more or less distinctly in radial rows. Some of these measured .25 by .16, .25 by .15, .24 by .13, .20 by .15, .20 by .13, .18 by .14, .18 by .11, .17 by .15, .16 by .12, .16 by .11 mm.

Two good specimens of this species, with several fragments, were taken at Station 318, in 337 fathoms, N. Lat. 31° 48′ 50″, W. Long. 77° 51′ 50″.

Family GORGONIDÆ.

Stenogorgia, gen nov.

Axis horny, branched. Cœnenchyma thin, consisting chiefly of small, warty, fusiform spicula, with a few smaller, short, irregular, rough, granule-like spicula next the outer surface, but not forming any regular layer. Calicles scattered or two-rowed, more or less prominent, eight-rayed at summit, and filled with spicula, like those of the cœnenchyma. Tentacles filled with fusiform spicula and usually incurved, commonly not retracted within the calicles, but capable of it.

This genus externally resembles *Thesea* and *Eunicella*, but in the former the cœnenchyma has a superficial layer of scales, and in the latter it has a regular external covering of club-shaped spicula, standing perpendicular to the axis. In *Swiftia*, which has a similar appearance, the cœnenchyma consists of small scales only. Its affinities are, apparently, with *Leptogorgia*.

Stenogorgia casta Verrill, sp. nov.

Plate II. Figs. 1, 1 a, 1 b.

A small, delicate coral, pure white in alcohol, with rather prominent calicles, in two alternating rows. The base is expanded and adherent. The main stem divides dichotomously from near the base. The branches fork irregularly and unequally, or sometimes branch somewhat pinnately and sparingly. The branches and branchlets spread outward at a wide angle, and then curve upward; they lie nearly in one plane, and do not differ much in size, the terminal ones often being the largest. The axis is nearly round, chestnut-brown in the larger branches, pale yellowish in the terminal ones. The calicles are prominent verruciform, or broad-conical, and form a close row along each edge of the branches, but those in one row do not lie precisely in a plane, for they alternately face a little to the front and to the rear; those on opposite margins of the branches alternate, and as the swollen bases of the calicles are in contact the edges of the branches show a zigzag outline; the calicles are narrow at the summit, in the preserved specimens, and are closed by eight convergent segments, and in most cases they are surmounted by a small round cluster of incurved tentacles, which show their outer surfaces filled with convergent spicula. The largest specimen is 100 mm. high, and 120 mm. broad; diameter of the branches, including calicles, 2.5 to 3 mm.

The spicula of the cœnenchyma and calicles are rather small, fusiform, often bent, irregularly covered with more or less numerous prominent warts; some of these spicula are elongated and acute at both ends; others are stouter and more obtuse; the longer spicula measure .32 by .06, .28 by .05, .28 by .045, .23 by .05, .20 by .05, .16 by .03 mm.; the stouter ones, .21 by .06, .20 by .07, .17 by .06, .15 by .06, .11 by .045 mm. In the tentacles there are numerous slender, mostly bent and sparingly warted or spinulated spicula, acute at one or both ends, with some that are larger, blunt, and roughly warted at one end, and others roughly warted all over; flattened oblong spicula, some of them with roughly warted borders, also occur. The slender, smoothish spindles of the tentacles measured were .23 by .02, and .19 by .015 mm.; the stouter and rougher ones, .26 by .05, .26 by .03, .19 by .04, .16 by .03, .14 by .03 mm.; the flattened oblong ones, .10 by .05, and .10 by .04 mm.

Station 318, in 337 fathoms, N. Lat. 31° 48′ 50″, W. Long. 77° 51′ 50″, 1880.

Family MURICEIDÆ.

Acanthogorgia Gray.

Proc. Zoöl. Soc. London, for 1857, p. 128.

Blepharogorgia Duch. & Mich., Supplément Mém. Corall. des Antilles, in Mém. Turin Acad., XXIII., 1864–66, p. 109.

Coral variously branched, usually slender and flexible. Cœnenchyma thin, filled with fusiform spicula, sometimes having one end projecting as spinules

from the surface. Calicles elongated, tubular, often expanded at the end, and armed with eight long, projecting, spiniform spicula, or clusters of spicula, which are enlarged and bent at the base, but not lamelliform; sides of the calicles usually eight-ribbed, and covered with fusiform spicula.

This genus has been more or less confounded with *Paramuricea* by several authors. To that genus it is closely allied, differing chiefly in the longer calicles and their longer marginal spines, and in having slender fusiform spicula without the irregular, flat, branched forms, characteristic of *Paramuricea.*

Besides the species herein described, this genus includes *Acanthogorgia hirsuta* Gray, the type of the genus, recorded by Johnson from off Madeira, and *A. Schramii* (Duch. & Mich. sp.) from the West Indies. Other species wrongly referred to the genus by Johnson and Pourtalès are mentioned under *Paramuricea.*

Acanthogorgia armata Verrill.

Acanthogorgia armata Verrill, Amer. Jour. Sci., XVI., 1878, p. 376; XXIV., 1882, p. 364.

Plate III. Figs. 1, 1 a, 1 b, 2, 2 a, 2 b.

Coral slender, flexible, much and irregularly branched, bushy and shrub-like, often with the branches somewhat in a plane, and occasionally uniting. Cœnenchyma thin, filled with rather small, white, often curved, warted, fusiform spicula, which do not project from the surface in spine-like points. Calicles usually very much elongated, the length often six to eight times the diameter, clavate, or capitate, smallest near the base and suddenly enlarged near the summit, which is surmounted by eight groups of long, divergent, sharp, spine-like spicula, with their projecting points nearly smooth; sides of calicles with eight low ridges or angles covered with elongated, warty spicula, having an irregular, chevroned arrangement, but usually not projecting from the surface as spines, or but slightly so.

In a few cases marked variations have occurred in the form of the calicles on different branches of the same specimen (see Figs. 1, 1 a, 1 b). In these cases, on part of the branches they are of normal shape and size (Fig. 1), while on other branches they may be much shorter, cylindrical, or even swollen in the middle and not enlarged at the end (Fig. 1 b); but on still other branches they may have intermediate forms (Fig. 1 a). On the specimen from which these figures were made the calicles were rougher or more spinose along the sides than usual.

Height of one of the original examples, 200 mm. (about 8 inches); breadth, 150 mm. (about 6 inches); length of calicles, 5 to 8 mm.; their diameter at base, .8 to 1 mm.; at summit, 1 to 1.5 mm. Much larger examples have since been obtained, some of them 1500 mm. (about 20 inches) high, and half as broad.

The specimens of this species brought from the fishing banks off Nova Scotia and Newfoundland by the Gloucester fishermen vary considerably in the mode of branching. The largest specimen from the Grand Banks is eighteen inches high and twelve broad. It has a rudely fan-shaped form, the branches being nearly in one plane, but the terminal branchlets are very unequal in length, crooked and flexible; they are so numerous and so irregular in their origin and direction as to produce a bushy appearance. Five large main branches arise near together, close to the base; these are 5 to 8 mm. in diameter; some of them fork again, beyond the middle; the divisions that they give off are large and small, strongly divergent or divaricate lateral branches or pinnæ, which divide and subdivide in the same way; besides these there are many small, irregular, crooked and slender branchlets, 25 to 50 mm. (1 to 2 inches) in length, which are mostly unbranched, but bear long, slender, divaricate calicles, less close than those of the branches. Calicles also spring directly from the main branches, and still more numerously from the secondary ones, and on all sides of them.

In a smaller specimen, from lot 804, there are nine large branches and three smaller ones springing from the base.

In a small specimen, from lot 791, there are two primary branches from the base. In this the calicles are short and hardly pedunculate, except in certain parts, where they are somewhat so.

In one from lot 866, the branches and calicles are unusually slender.

In a specimen from lot 808, there is but a single main stem, and the branching is more irregular and bush-like. In this the calicles are shorter, thicker, scarcely pedunculated, and rather closely crowded on the terminal branchlets, while on other branches they are nearly as long as on the ordinary or more typical specimens. (Plate III. Figs. 1–1 b.)

In another example, from lot 364, the main stem divides once near the base, and the coral is shrub-like, not branching in a plane; the branches are slender, widely divergent, crooked. The calicles are scattered, slender and pedicelled.

In life, the color is bright salmon; when dried, it is usually ash-gray; in alcohol, dark gray or ash-brown.

The larger spicula of the calicles (Fig. 2 b, *c*, *d*, *e*) are varied in form and size, mostly long, rather slender, some straight, others crooked, often bent abruptly in the middle, or toward one end; they are strongly spinulated, except near the outer end, which is usually slender and very sharp; the inner end is stouter, more or less blunt, sometimes irregularly slightly bilobed, and usually sharply spinulated, but not branched. Some of them are strongly spinulated throughout; others, for less than half their length (Fig. 2 b, *e*); these are usually angularly bent near the middle; the blunt and spinulated end is imbedded, and the smoother, sharper, and acute end projects from the surface, near the summit of the calicle. Some of the largest of these measured 1.62 by .10, 1.05 by .10, 1.00 by .07 mm.; the straight ones, 1.52 by .10, 1.32 by .06, .99 by .10 mm. With these were smaller, more or less crooked, slender, fusiform spicula,

strongly and sharply spinulated over the whole surface (Fig. 2 b, *g*). Some of these measured 1.52 by .10, 1.52 by .07, 1.28 by .07, .90 by .05 mm.

In the flexible part of the polyps and the bases of the tentacles there is an abundance of long, fusiform, more or less curved, and strongly spinulated spicula, mostly acute at both ends, and moderately slender, but some of them are much stouter in form, and many are enlarged, flattened, and somewhat lacerately spinulated at one end; some compound forms also occur, but these also take an irregularly fusiform shape. Some of the curved ones, surrounding the polyp-body, measured .86 by .05, .86 by .038, 76 by .07 mm.; the straighter ones, .80 by .10, .80 by .07, .76 by .07, .71 by .07, .70 by .05, .62 by .05, .62 by .038 mm.

Three specimens, of moderate size, and partly overgrown by sponges, were taken by the Blake, at station 309, off Nantucket, in 304 fathoms. To these were also attached *Astrochele Lymani; Ophiacantha; Pecten vitreus;* a handsome *Scalpellum*; and the fresh eggs of a black dog-fish (*Scyllium*). Another example, from station 306, in 524 fathoms, had similar things attached.

It was dredged by the U. S. Fish Commission, in 1882, off Martha's Vineyard, in 640 fathoms.

Several fine specimens have been brought from the deep fishing banks off Nova Scotia and Newfoundland by the Gloucester fishermen, during the past four years, and presented to the U. S. Fish Commission.

The first specimen was taken off Nova Scotia, in 300 fathoms, by Captain T. Goodwin (schooner "Elisha Crowell"). The second specimen was obtained off George's Bank, in about 220 fathoms, by Captain Anderson and crew of the schooner "Alice G. Wonson."

The following specimens were dredged by the Blake in 1880: —

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
306	524	41° 32′ 50″	65° 55′	1 medium.
309	304	40° 11′ 40″	68° 22′	3 "

The typical species of this genus, *A. hirsuta* Gray, was obtained in deep water, off Madeira. It is closely related to *A. armata*.

Two species closely allied to these were dredged in deep water, in the West Indian seas, by the Blake, in 1878–79. One of these, *A. aspera*, was described by Pourtalès, in 1867.

Acanthogorgia aspera Pourtalès.

Acanthogorgia aspera Pourtalès, Bulletin Mus. Comp. Zoöl., I., 1867, p. 113.

The original specimen of this species, described by Pourtalès, is small and slender, and probably young; several unequal, widely divergent branches are given off laterally from the main stem, which also bears isolated calicles along the edges between the branches; some of the branches begin to divide in the same manner. Axis brownish yellow. Cœnenchyma thin, filled with acute

fusiform spicula, mostly with one end turned outward and projecting from the surface of the cœnenchyma in the form of slender, sharp points or spinules, giving the surface a very rough appearance. Calicles elongated, relatively large, mostly slightly constricted toward the summit, which is considerably enlarged and armed by numerous slender, very sharp, divergent spicula, which form eight clusters. Sides of the calicles with eight ribs, and covered with long, slender, very acute spicula, many of which have the sharp tips projecting from the surface, especially toward the base and along the ribs.

Height, 55 mm.; breadth, about 25 mm.; length of the larger calicles, about 3 mm.; diameter, about 1 mm.

Taken off Havana, in 270 fathoms, by the "Bache," in 1867.

Acanthogorgia muricata Verrill, sp. nov.

Coral moderately slender, flabellate. The stem usually divides, not far from the base, into several principal branches, which diverge widely at first and then ascend nearly vertically; these give off numerous lateral branches, which often diverge nearly at right angles, many of them again subdividing in a similar manner. Axis yellowish brown, strongly striated. Cœnenchyma thin, grayish white in alcoholic specimens, and having a loose granulous appearance, composed of small, rough, irregular, and rather large, very roughly warted or spinulose fusiform spicula; many of the latter are crooked and are placed at all angles, but do not have projecting ends. The calicles are elongated, cylindrical, or somewhat expanded at the summit, and armed by about eight very long slender, sharp, projecting, and divergent spicula, the projecting part being usually more than two thirds the length of the calicle. Sides of the calicles covered with rather slender, elongated, warty, fusiform spicula, many of which are strongly curved; and these are arranged so as to form eight longitudinal ridges; the ends of some of the spicula frequently project from the surface, toward the summit.

Height of an ordinary specimen, about 175 mm.; breadth, about 100 mm.; length of the calicles, mostly about 3 mm.; diameter, 1 mm.

Taken at station 272, in 76 fathoms, off Barbados, by the Blake, in 1878–79, and in several other localities in the same region.

This species is closely related to *Acanthogorgia armata*, but is more slender and has smaller and less prominent calicles, which are armed with longer and more acute spicula. The spicula of the cœnenchyma are also different in form. It differs from *A. aspera* in not having the calicles and cœnenchyma hispid with slender spines.

Paramuricea Kölliker.

Icones Histiol., I., 1865, p. 136. (Type, *P. placomus.*)

Coral variously branched, often large. Cœnenchyma usually thick, filled with rough, fusiform, oblong, and irregular spicula, some of which often pro-

ject from the surface as small spinules. Calicles short-cylindrical or verruciform, armed at summit by a circle of short projecting spinules, which are formed by the distal ends of large spicula having a large, irregular, flattened, usually lobed or branched basal portion ; sides of calicles with rough spicula, part of them irregular and flattened. Bases of contracted tentacles form eight triangular, convergent lobes, filled with spicula arranged in chevron ; a circle of curved transverse spicula surround the bases of these tentacular lobes.

This genus is a very characteristic one, in somewhat deep water, in all parts of the North Atlantic and in the Mediterranean. A large number of specimens, belonging to several species, were taken by the Blake in the Caribbean Sea and Gulf of Mexico, in 1877–79. Some of these are allied to our Northern forms, and are therefore included here. Some of the species that have formerly been referred to *Acanthogorgia* belong properly to *Paramuricea*. Among these are the following : —

Paramuricea Grayi (Johnson sp., 1861). Off Madeira.
Paramuricea Atlantica (Johnson sp., 1862). Off Madeira.
Paramuricea hirta (Pourtalès sp., 1867). Off Cuba.

Paramuricea borealis Verrill.

Paramuricea borealis Verrill, Amer. Jour. Sci., XVI., 1878, p. 213 ; XXIV., 1882, p. 364.

Plate III. Figs. 4, 5, 5a.

The original specimen of this species was small, with a low, bushy growth. Subsequently a considerable number of examples have been obtained, of larger size and taller growth, but agreeing in the form and arrangement of the calicles, and in the spicula.

When well developed this species grows in a somewhat flabellate form, the branches several times forking and having a tendency to lie in one plane. The larger branches diverge rather abruptly at their origin, and then ascend in a curve ; the smaller branches and branchlets are widely divergent, or divaricate, often spreading at right angles. The branches are rather distant, not very numerous, often crooked, and decidedly slender in most specimens, but in a few examples they are stouter than usual, and not unfrequently they are larger near the tips and have the calicles more numerous there, while over the branches generally they are usually distant, leaving much of the cœnenchyma bare. Occasionally they are closer than usual over most of the branches, giving them a stouter appearance.

The calicles (Fig. 5) are short, stout, cylindrical verrucæ, about as broad as high, crowned by a marginal circle of about eight short but acute spines, with a few other similar ones around the upper part, below the margin, but not extending far down the sides, so that the lower part of the calicles is not spinose, or only very slightly so. The calicles are composed of variously shaped, irregular, rough-edged spicula, mostly rather small, below the marginal spines.

Within the margin there are several transverse or circular rows of long, slender, pretty regularly curved, or bow-shaped, warty spicula, which surround the upper or marginal part of the partially retracted polyps, at the bases of the tentacles, which are themselves strengthened externally by two convergent rows of similar, but less curved spicula, so arranged as to form eight convergent ∧ -shaped groups over the contracted and incurved tentacles.

The cœnenchyma is thin, not at all spinose, and filled with small, very irregular, rough spicula, many of which are crooked ; these spicula give the surface a rather finely and roughly granulous appearance under a lens. The axis is slender, soft and dark brown, and shrinks much when dried.

In life the color is light orange or salmon. In alcohol it becomes dark grayish brown or umber-brown. When dried the color is often dark brown or nearly black.

One of the larger specimens is 280 mm. (about 11 inches) high ; breadth, 90 mm. ; diameter of main stem, 3 mm. ; of branchlets, 1 to 1.5 mm. ; of calicles, 1 mm. The variety with stouter branches has branchlets 2 to 4 mm. in diameter, including the calicles.

The large spicula around the edge of the calicles (Fig. 5 a, *c*, *d*, *e*) have a large, broad, flat, variously and deeply lacerately lobed and incised, imbedded basal portion, and a rather short, moderately stout, acute, somewhat rough or warty terminal portion, which projects from the surface. The basal portion is frequently longer than the point, and often broader than long ; it is palmately divided into three to six, or more, irregular main divisions, which are very unequal in size and breadth, and variously subdivided and lobed ; some of the lobes may be broad, and others narrow, some acute, and others truncated or obtuse, and not unfrequently they coalesce, enclosing irregular openings. Some of these spicula measure 1.14 by .57, .95 by .38, .84 by .61, .82 by .48, .76 by .66, .76 by .32, .66 by .28, .61 by .32, .57 by .48, .57 by .32 mm.

With these are other smaller, rudely oblong, flat spicules (Fig. 5 a, *g*), which have no projecting point, or only a very short one, but are rudely and strongly lobed, along the sides and at one or both ends, the lobes being more or less sharp, rough and incised. These are variable in size ; some are .76 by .38, .52 by .34, 50 by .16 mm.

Just inside the margin of the calicles there are several transverse or circular rows of long, slender, roughly warted spicules (Fig. 5 a, *f*), tapering and acute at both ends, and curved in the middle ; these form a continuous band or ring around the base of the free part of the polyps. The larger of these measure 1.28 by .06, 1.05 by .095, 1.05 by .06, .82 by .07, .82 by .05 mm. Above these there are eight convergent, triangular or ∧ -shaped groups of similar long, fusiform, warty, mostly crooked spicules, but they are not so strongly nor so regularly curved, the bend being usually nearer the proximal end ; these correspond with the stems of the eight tentacles ; some of them are divided at the base into two lobes or rough branches. The larger of these measure 1.24 by .07, 1.08 by .08, 1.01 by .07, .95 by .07, .86 by .08 mm. ; one of the long ones with forked base is 1.05 by .06 mm.

The cœnenchyma is composed mainly of smaller, rudely warted and spinulated, irregular, more or less fusiform, and often crooked spicules, varying much in size and shape (Fig. 5 a, *i–l*). Some measured .76 by .14, .57 by .10, .57 by .08, .55 by .10, .44 by .05, .38 by .14, .28 by .14 mm. With these are some that are forked or bilobed (.63 by .24, .52 by .24 mm.), and a few compound ones, all roughly warted.

This species was dredged off Martha's Vineyard by the U. S. Fish Commission, in 1882, in 234 fathoms. A number of specimens have been obtained by the Gloucester fishermen, from the fishing banks off Nova Scotia, and from the Grand Banks, in deep water. The original example was from the Grand Banks, with *Primnoa reseda*.

Paramuricea grandis VERRILL, sp. nov.

Plate III. Figs. 3, 3 a, 3 b.

This is a large, stout, subflabellate species, growing to the height of two feet or more, with the main branches often half an inch or more in diameter. The branches fork several times, diverging widely at the axils, and then ascending, and having a tendency to lie nearly in one plane.

The branches are much stouter and the calicles more numerous than in *P. borealis*; they are usually nearly in contact at their bases, leaving very little of the cœnenchyma exposed, and are seldom separated by spaces equal to their diameters. The calicles form prominent verrucæ, swollen at the base, and scarcely as high as broad; the margin is crowned by eight slight, angular denticles, from which the small marginal spines scarcely project in alcoholic specimens, and only slightly in dry ones; the sides of the calicles are nearly smooth except near the margin.

In alcoholic specimens the whole surface of the calicles and cœnenchyma is covered with a nearly smooth soft dark brown skin, concealing the spicula. The polyps are capable of being entirely retracted within the calicles. Many are, however, only partially retracted, and show the circular series of slender bow-shaped spicula around the polyps and the convergent groups of slender curved spicula on the tentacles, as in *P. borealis*, but they are smaller in this, and not at all spinose.

The cœnenchyma is rather thick, but filled with irregular spicula, many of which are flat and irregularly lobed and branched. The axis is black in the main branches; soft and yellowish brown in the smaller ones. When dried the cœnenchyma is dark brown or nearly black.

The projecting, flattened, spinose spicules of the calicles (Fig. 3 a, *c*, *d*) have rather broader, flatter, and stouter points than those of the preceding; the point which projects is roughened or rudely spinulated along the edge; the basal portion is strongly flattened, commonly longer than broad, and usually comprises considerably more than half the whole length; it is sometimes oblong, sometimes more or less triangular; the sides and base are more or less deeply

incised or lobed, the divisions are partly acute, and are numerous and narrow, but not very long, and many are again divided into smaller lobes and rough points. These measured .86 by .28, .77 by .33, .77 by .29, .67 by .29, .62 by .24, .57 by .19, .48 by .21 mm. They are accompanied by smaller, irregular, lobed and incised flat spicula, and by still smaller roughly warted spindles.

In the cœnenchyma there are many rather large, flat, rudely oblong or irregular, rough spicules (Fig. 3 a, *i*, *j*, *k*), of various sizes, which are strongly and irregularly lobed and incised, all around; they vary greatly in shape, but have no projecting point. Some of these measured .67 by .33, .62 by .33, .57 by .24, .53 by .29, .53 by .24, .42 by .24, .43 by .19 mm. These are mingled with and more or less concealed by smaller, roughly warted spindles, which are often crooked.

The arched transverse spicula (Fig. 3 a, *h*), within the margin of the calicles, are long, slender, finely warted, strongly bent in the middle, tapered and acute at both ends. Some of these measured .90 by .05, .80 by .038, .76 by .05 mm.

The convergent spicula from the polyps and bases of the tentacles (Figs. 3 a, *g*, 3 b) are similar but less curved, and the largest of them are a little stouter. Some of these are .85 by .07, .76 by .038, .71 by .05 mm.

Two specimens, of large size, were taken at Station 306, off George's Bank, in 524 fathoms, N. Lat. 41° 32′ 50″, W. Long. 65° 55′. The larger one is over 2 feet high (620 mm.) and 18 inches (456 mm.) broad.

One of these had many of the branches dead, and incrusted by a small variety of *Epizoanthus Americanus;* on it there were also specimens of an actinian (? *Urticina*, sp.) and of a barnacle (*Scalpellum*).

A large dead and denuded gorgonian, probabably this species, from Station 317, in 333 fathoms, N. Lat. 31° 57′, W. Long. 78° 18′ 35″, is curiously covered, over nearly its whole surface, by small confluent actiniæ (Plate VI. Fig. 9).

Several fine examples, some of them of large size, have been brought from the fishing banks, off Nova Scotia, by the Gloucester fishermen, and presented to the U. S. Fish Commission.

Paramuricea tenuis Verrill, sp. nov.

Coral rather slender, flabellate, thickly branched, the branches occasionally coalescent, the main branches ascending and giving off numerous much smaller, widely divergent lateral branches, which mostly divide again in the same manner ; final branchlets slender. Axis soft, light brownish yellow, finely striated, having a wood-like appearance. Cœnenchyma thin, dull gray or brown in alcoholic specimens, filled with a great abundance of rather small, fusiform and irregular-shaped, often bent, very roughly warted spicula, which lie at all angles, one end of many of them projecting slightly from the surface as small conical spinules. Calicles not crowded, mostly arranged along the edges of the smaller branches and branchlets in a single row on each side, small, short, cylindrical or verruciform, usually swollen at the base, the sum-

mit conical in contraction, consisting of eight clusters of acute, convergent spicula, corresponding to the bases of the tentacles and surrounded by a circle of slender curved spicula, just within the margin. The spicula forming the sides of the calicles are mostly fusiform and very roughly warted; those at the margin project but little.

Height of a moderate-sized specimen, 160 mm.; breadth, 150 mm.; diameter of the stem near the base, 3 mm.; of the branchlets, without the calicles, .75 mm.; diameter of the calicles, .6 mm.; height, about .5 mm.

Taken at Station 272, in 76 fathoms, off Barbados, by the Blake, in 1878–79, and at several other localities in the same region.

This species is allied to *P. borealis*, but is more slender, and has smaller spicula, which are different in form, and the surface of the cœnenchyma is spinulose.

Family PLEXAURIDÆ.

Eunicella modesta Verrill, sp. nov.

Plate II. Fig. 3.

Coral small, sparingly branched, nearly in a single plane, with large, low, round-topped, verruciform calicles. Base expanded, adhering to shells, etc. The main stem sends off a few branches, of about its own size; these spread abruptly at base, and then bend upward in a broad curve; they give off a few rather long, ascending branchlets, mostly from the outer curvature (in larger specimens these would probably divide farther in a similar way). The axis is round, horny, dark chestnut-brown in the larger branches, soft and yellow in the smaller ones. The calicles are rather large, low, rounded verrucæ, forming a close double row along each margin of the branches; they are mostly in contact, or nearly so, at their bases, in the rows, but leave a narrow, irregular, barren zone along the middle of the sides ; the tentacles are entirely retracted and the aperture is usually completely closed up, so that the summit of the calicle is evenly rounded, or shows only a slight pit in the centre ; sometimes it shows eight faint grooves and ridges. The entire surface is covered with the exposed, smooth, rounded, outer ends of the club-shaped spicula, forming the outer layer; these give the surface an evenly, regularly, and finely granulated appearance, under a lens. The color is white in alcohol.

The largest specimen is 120 mm. high and 65 mm. broad; diameter of the branches, 2.5 to 3 mm.

The club-shaped spicula (Fig. 3, *a*) of the cœnenchyma are remarkable for the smoothness and evenly rounded form of the larger end ; at the smaller end there is usually a single group of small warts; sometimes there is another whorl a little higher up. These clubs mostly measure from .13 to .16 mm. in length, and .03 to .05 mm. in greatest breadth. There are also some double-headed warty spicules (Fig. 3, *c*), about .15 by .07 mm. ; a few compound double-spindles, about .25 by .03 mm. ; and some simple, warty, fusiform

spicula or spindles (Fig. 3, *b*), usually acute at one or both ends, and more or less curved; the larger of these measure about .25 by .03 mm. to .25 by .04 mm.

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
318	337	31° 48′ 50″	77° 51′ 50″	2

Family BRIAREIDÆ.

Anthothela Verrill.

Proc. Nat. Mus., II., 1879, p. 199.

Coral either incrusting or irregularly branched. Branched forms with a distinct spiculose axis, composed of fusiform spicula. Calicles prominent, not capable of being contracted within the cœnenchyma, eight-lobed at the summit.

Anthothela grandiflora (Sars) Verrill.

Briareum grandiflorum Sars, Fauna Litt. Norvegiæ, p. 63, pl. 10, figs. 10–12.
Anthothela insignis Verrill, Check List Mar. Invert. N. England, 1879, p. 15.
Anthothela grandiflora Verrill, Notice of Recent Addit. to Mar. Invert., Part I., in Proc. National Mus., II., 1879, p. 199.

Plate IV. Figs. 6, 6 a.

This species grows in various irregular shapes. It sometimes spreads over and completely incrusts shells, pebbles, sponges, hydroids, and especially the dead and denuded axes of gorgoniæ, particularly of *Ceratoisis ornata* and *Paragorgia arborea.* At other times it grows up into more or less slender sparingly and irregularly branched forms, the branches often reuniting, and several inches in length. When incrusting gorgoniæ it is apt to run out beyond the ends of the gorgonian branches, continuing them by branches of its own. The cœnenchyma is rather thin, firm, and coriaceous, composed of irregular longer and shorter coarsely and roughly warted fusiform and oblong spicula.

The axis, in the branched forms, is sufficiently distinct, though not very different from the cœnenchyma in consistency; it is composed of strongly and roughly warted fusiform spicula similar to those of the cœnenchyma, but mostly more slender and with fewer warts; these are rather compactly crowded together. The calicles are large and prominent, usually, in alcoholic specimens, hour-glass shape, largest distally, and with a constriction near the top below the bases of the tentacles; sometimes they are verruciform; the upper part is eight-lobed, and more or less eight-ribbed. The tentacles are commonly incurved and contracted in the form of eight convergent lobes on the top of the calicles. They are filled with numerous large, fusiform, warty spicula. The calicles are filled with roughly warted spicula (Fig. 6 a, *g*, *h*),

similar to those of the cœnenchyma ; they are arranged in convergent series along the ribs of the distal portion of the calicles, beyond the constriction.

Color, in life, pale yellow or buff ; in alcohol, it is white, or yellowish white.

This species has been obtained in several instances by the Gloucester halibut fishermen in deep water, on the fishing banks, off Nova Sootia, and presented to the U. S. Fish Commission. It was first obtained by Captain N. McPhee and crew of the schooner " Carl Schurz," off Sable Island.

It was dredged, in 1881, by the U. S. Fish Commission, off Martha's Vineyard, at Station 1031, in 255 fathoms. It was not dredged by the Blake.

Anthomastus grandiflorus Verrill.

Anthomastus grandiflorus Verrill, Amer. Jour. Sci., XVI., 1878, p. 376.

Plate I. Figs. 7, 8, 9, 10, 10 a, 10 b.

Thirty-three specimens were taken at Station 329, off Beaufort, N. C., in 603 fathoms.

Many of these are very young, and are decidedly unlike the adult in appearance. They have a rather narrow peduncle, expanding upward to the broader, convex or flattened summit, where there are only three to five large polyps, arranged remotely around the margin, leaving the central area of the summit covered with numerous small asexual zoöids. Some of these young have the peduncle short, but in others it is remarkably elongated (Fig. 8). In all cases it terminates at the base in several, often numerous, lobulate branches, which are more or less subdivided into lobes, irregular in form and size, but mostly having small constricted bases, so that they are easily broken off. In most cases the polyps are still expanded, but in some they are all retracted. The color is dark red.

The smallest specimen obtained has two well-developed polyps, and two others just budding out. Similar specimens were dredged in large numbers, off Martha's Vineyard, in 1881, in 410 to 458 fathoms.

The specimens from the fishing banks, off Nova Scotia, both large and small, are mostly attached to stones by a broad incrusting base. In the larger specimens the peduncle becomes short, and the upper or polypiferous part large, round and convex, or capitate, often several inches in diameter and height, with twenty or more polyps scattered over the surface, but with a more or less marked tendency to form one or more rows around the border and to leave the central area comparatively bare. The surface of the cœnenchyma is finely granulous, with a great abundance of small red spicula, which make the texture firm and somewhat rigid. The polyps are very large, with long tentacles, but they are capable of entire retraction, though often exsert in alcoholic specimens. When the polyps are entirely retracted there are no prominent calicles, although the parts around the eight-rayed apertures are often swollen.

In partial contraction the contracted polyps, with their tentacles, often form large verrucæ.

Small zoöids are scattered over the surface between the polyps; sometimes these are prominent, in the form of small verrucæ; at other times they are so contracted as to be inconspicuous. The color is red, varying from bright cherry-red to dark red.

A well-grown specimen, but not the largest examined, measured across the polypiferous summit, 82 mm.; diameter of peduncle, 50 mm.; height of peduncle, 30 mm.; of polypiferous mass, 30 mm.; length of polyps as expanded in alcohol, 36 mm.; diameter of body, 7 to 9 mm.; breadth across expanded tentacles, 25 to 30 mm. (about 1 to $1\frac{1}{4}$ inches). The tentacles and their pinnæ are filled with slender fusiform or needle-shaped acute spindles.

The red spicula of the external part of the cœnenchyma are abundant, of various forms, but mostly rather small, and very roughly warted. The largest are irregular, oblong and fusiform, roughly and unevenly spinulated spicula (Fig. 10 a, *c*), sometimes swollen in the middle, sometimes near one end; the warts or spinules are usually large and prominent, but scattered and unequal; on some of the longest and most regular fusiform spicula they are smaller and more regular. The former measure .20 by .06, .20 by .03, .19 by .04, .18 by .05, .17 by .06, .15 by .05 mm.; the latter, .33 by .05, .32 by .03, .30 by .03 mm. With these (Fig. 10 a, *d*) there are large numbers of much smaller, short, very rough spicula (double-heads) with a narrow naked space in the middle and a whorl of long, sharp, rough warts near each end; some of these have each end terminated by a cluster of rough spinules; others are a little longer, with the ends acute, or with two or three spinules. The double-heads measure .09 by .07, .08 by .06, .08 by .05, .07 by .06, .07 by .05 mm. Among these there are also some small, rough, four-parted or cross-shaped spicula, of similar size.

The spicula of the interior of the cœnenchyma are similar, but larger and more strongly warted spindles (Fig. 10 b, *g*) and double-heads (Fig. 10 b, *f*). With these there are, however, numerous rough and coarsely marked club-shaped spicula (Fig. 10 b, *e*), some of them elongated, others much shorter; they have whorls of rough prominent warts at the larger end, becoming smaller toward the smaller end, which is acute. The larger fusiform spicula measure .36 by .08, .35 by .06, .28 by .09, .26 by .08, .23 by .08, .18 by .07 mm.; the clubs measure .19 by .08, .18 by .08, .16 by .06, .15 by .08, .13 by .07, .11 by .06 mm.; the double-heads, .13 by .08, .12 by .07, .08 by .05 mm.

The Gloucester fishermen first collected this species on the deep-water fishing banks, off Nova Scotia, in 1877 and 1878. Since that time they have brought in numerous specimens and presented them to the U. S. Fish Commission. These have come from off George's Bank, Le Have Bank, Banquereau, Sable Island Bank, Grand Bank, etc., in 150 to 300 fathoms. Numerous specimens were dredged by the U. S. Fish Comm. steamer Fish Hawk, off Martha's Vineyard, in 410 to 458 fathoms, 1881. It was also dredged in the Caribbean Sea by Mr. A. Agassiz, on the Blake, in 1878–79.

List of specimens dredged by the Blake, 1878-80: —

Station.	Fathoms.	Locality.	Specimens.
1878-79.			
190	524	Off Dominique	1, good size.
196	1030	Off Martinique	1 young.
227	573	Off St. Vincent	1 "
265	576	Off Grenada	1 "
1880.			
329	603	N. Lat. 34° 39′ 40″, W. Lon. 75° 14′ 40″	33, mostly young.

Family ALCYONIDÆ.

Eunephthya Lütkeni (Marenz.) Verrill.

Alcyonium glomeratum Lütken, MSS. (*non* Johnston).

Eunephthya glomerata Verrill, Amer. Jour. Sci., XLVII., 1869, p. 284; Proc. Essex Inst., VI., 1869, p. 97.

Ammothea Lütkeni Marenzeller, Denk. Akad. Wien, XXXV., 1878, p. 272 [16].

Alcyonium Lütkeni Verrill, Notice of Recent Addit. to Mar. Invert., Part I., in Proc. Nat. Mus., II., 1879, p. 200.

Plate IV. Figs. 7, 7 a.

The main stem is upright, without polyps, giving off cylindrical branches along the sides; from these, small lateral branchlets arise all along the sides as well as at the ends, each bearing a cluster of three to five, or more, prominent polyp-calicles, which are larger than in *A. carneum*, and, when contracted, are obovate, incurved, and show the bases of the eight tentacles as small terminal lobes. The surface or outer layer of the polyp-bodies and bases of the tentacles is filled and covered with spicula, so as to render them decidedly rough, rigid, and incapable of complete contraction. The calicles are more or less distinctly eight-ribbed; the stouter spicula project slightly in rough points along the ribs, while those in the intervals, which are more slender, fusiform and warted, are imbedded in the integument.

The cœnenchyma is rather firm and stiff, due to the abundance of the spicula. The larger spicula (Fig. 7 a, *b*) are rather large, long, stout, mostly club-shaped in form, with the smaller end thickly covered with small warts, and the large end covered with large, roughly lacerate warts, sometimes taking the form of ragged spinules, in other cases having the form of lacerate, flattened lobes; with these are some roughly warted fusiform spicula, of similar size (Fig. 7 a, *c*), and numerous smaller rough spicula, some of which are fusiform (Fig. 7 a, *d*) and others club-shaped, some of them slender and others stout.

Height, in alcohol, 60 to 80 mm. or more (about 3 inches); breadth, 35 to 50 mm.; diameter of contracted calicles, 1 to 1.25 mm.

One small specimen was dredged by the Blake, at Station 339, in 1186 fathoms, off Delaware Bay. Several examples were dredged in 1877, off Halifax, N. S., in 52 fathoms, by the U. S. Fish Commission. Several good

specimens have been obtained and presented to the U. S. Fish Commission by the Gloucester fishermen, from the deep fishing banks off Nova Scotia. Greenland (Lütken, Mus. Copenhagen).

The specific name (*Lütkeni*) was given to this species independently by Marenzeller and myself, at nearly the same time.

A species of this genus, *E. nigra* (= *Nephthya nigra* Pourt., 1868), closely allied to the above, occurs in 120 to 152 fathoms, in the Straits of Florida. It has a similar arrangement of calicles, but the latter, when contracted in alcohol, are a little larger, and not incurved, but stand out straight, showing eight symmetrical, convergent lobes at the summit, from which eight rather prominent spiculose ribs extend down the sides.

Gersemia longiflora Verrill, sp. nov.

Plate III. Figs. 6, 6 a, 6 b.

Coral tall, flexible, branched. The main stem has a naked basal portion, which expands below into a thin, membranous, hollow, cup-shaped basal disk, clasping mud. Stem cavernous, upright, giving off, on all sides, numerous unequal lateral branches; the larger branches subdivide in the same manner as the main stem, and some of these secondary divisions may again divide. The ultimate branchlets consist of three to five or more long, cylindrical or tubular calicles, usually collapsed in alcoholic specimens; these are in contact at their bases, without any intermediate cœnenchyma. The calicles are directed upward and spread but little; in the preserved specimens the sides of the calicles show eight distinct rounded ribs, nearly obsolete near the base, but becoming more prominent toward the summit, and terminating in eight triangular lobes. Tentacles, in the preserved specimens, are contracted into a compact bunch at the summit of the calicles, but do not seem to be capable of being entirely concealed. The cœnenchyma of the main stem and principal branches has a finely granulous surface, due to small, rough spicula. The surface of the calicles is somewhat roughened by numerous small, rough, elongated spicula, which are arranged in chevron. Color, in alcohol, yellowish white, grayish at base.

The spicula vary greatly in size and form; the longer ones are long, slender, sparingly warty spindles (Fig. 6 b, *c*, *d*), and stouter spindles of nearly equal length, but with more numerous and larger, irregular warts; with these there are numerous shorter, prominently warted, fusiform spicula (Fig. 6 b, *e*) of equal diameter, and other short, warty spicula that are scarcely more than twice as long as broad; small spicula of many other forms also occur, and among these there are some compound ones (Fig. 6 b, *f*, *g*).

Height, 110 mm.; greatest breadth, 60 mm.; diameter of main stem at base, about 10 mm.; length of the calicles, 8 to 10 mm.; diameter, 1 to 1.5 mm.

Station 339, in 1186 fathoms, N. Lat. 38° 16′ 45″, W. Long. 73° 10′ 30″, Blake Expedition, 1880, 1 specimen.

ACTINARIA.

Adamsia sociabilis Verrill.

Adamsia sociabilis Verrill, Amer. Jour. Sci., XXIII., March, April, 1882, pp. 225, 314, 315.

Plate VIII. Figs. 2, 3.

Column slender and long in full expansion, very changeable, smooth, with pores (cinclidæ) near the base; disk a little wider than the column; tentacles small, slender, in two circles, often held alternately erect and recurved. Mouth often protruded.

Color of column translucent, and usually conspicuously striped with alternate pink and flake-white longitudinal bands, the latter narowing upward; tentacles pinkish; mouth with pink lips, crossed by darker lines, between the small lobes. Height in expansion, about 10 to 14 mm.

This species is always carried about by a small hermit-crab (*Catapagurus socialis* Smith, formerly *Hemipagurus*), as represented in our figure.

It starts upon a small shell, usually *Cadulus*, or a pteropod (*Cavolina*), occupied by the crab when young. The base becomes much expanded and bilobed, the lobes often surrounding the aperture of the shell, and uniting beneath.

The basal disk, as it enlarges, secretes a thin greenish or brownish chitinous pellicle, which covers the shell and extends far beyond its aperture, thus increasing the space for the crab. Eventually the shell is usually entirely dissolved or absorbed, and in its stead there is only the conical or hood-shaped horny pellicle, in which the crab protects his abdomen. The crab is an active species, and habitually exposes more of its body than is usual in the group. It is probably able to swim free. The disk of the actinian, usually, if not always, is held downward, beneath and behind the legs of the crab. This position would be favorable for obtaining its share of the food, when the crab is eating.

This species was taken by the Blake, at Station 344, in 129 fathoms, N. Lat. 40° 1′, W. Long. 70° 58′.

It was taken off Martha's Vineyard, at many stations, in 76–410 fathoms, by the U. S. Fish Commission, in 1880, 1881, and 1882.

Sagartia abyssicola Verrill.

? *Phellia abyssicola* Koren & Dan., Fauna Litt. Norvegiæ, III., 1877, p. 78, pl. 9, figs. 3, 4.

Sagartia abyssicola Verrill, Amer. Jour. Sci., XXIII., 1882, pp. 314, 315.

Plate VI. Figs. 1, 1 b, 1 c.

Base broad, adherent, expanded and thin at the edges, often clasping the tubes of *Hyalinœcia artifex*, and also attached to pebbles and shells. Column

in extension elongated, narrow in the middle, expanded at the summit, usually covered except near the summit with a rough, closely adherent coating of sand, foraminifera, etc., but some specimens are nearly naked. In contraction it may become low, broad-conical, sometimes nearly flat. Tentacles numerous, longer than the diameter of the disk, rather slender, acute, forming about three to five sub-marginal circles. Column dirty salmon or dull flesh-color; tentacles sometimes pale flesh-color, sometimes orange or salmon, frequently dark purplish brown, often with a darker streak on each side of the base in the paler examples; flake-white patches often occur between the bases, or at the margin, between the outer tentacles; disk usually darker orange-brown or purplish brown, with pale and dark brown radii. Pink thread-like acontia are emitted abundantly from pores scattered on the column, and from the mouth. The larger examples are often 25 to 35 mm. in diameter, and 40 mm. in height.

This was dredged sparingly by the Blake, at Station 310, in 260 fathoms, N. Lat. 39° 59′ 16″, W. Long. 70° 18′ 30″; and at Station 336, in 197 fathoms, N. Lat. 38° 21′ 50″, W. Long. 73° 32′. It was taken abundantly, in many localities, off Nantucket, Martha's Vineyard, and Delaware Bay, on pebbles, shells, dead *Echini*, worm-tubes, etc., in 75–640 fathoms, by the U. S. Fish Commission, in 1880, 1881 and 1882. It is usually the most abundant actinian in these depths. The *Actinia abyssicola* Moseley is probably a different species.

Sagartia Acanellæ Verrill, sp. nov.

Plate VI. Figs. 2, 2a.

A small orange-colored species, with numerous long slender tentacles, which, by its base, entirely surrounds and closely clasps the branches of *Acanella Normani*. In a view from above, the body is usually elongated elliptical, the longer diameter being in the direction of the branch, along which the basal membrane extends considerably beyond the body itself; the disk is also more or less elliptical and eccentric. In a side view the body is low and usually oblique, the end toward the distal part of the branch sloping more rapidly than the other; the sides are usually smooth, but sometimes show slight elevated ridges or small tubercles; the integument is more or less swollen, somewhat translucent, and shows the internal lamellæ as thin white longitudinal lines, with opaque, orange-colored reproductive organs between them, in the lower half. Upper margin nearly equal, even, well defined; a few small round points, on the sides, appear to be contracted pores (cinclidæ), but no acontia have been seen protruded. The base fits itself lengthwise to the crooks and angles of the branch to which it is attached; the edges of the basal disk completely unite by a close suture along the opposite side of the branch, and extend, in a tubular form, more or less along the branch, sometimes entirely covering up its tip. Tentacles very numerous and crowded in five, six, or more rows, long and very slender, in extension, often, even in alcoholic speci-

mens, with long filiform tips, at other times shorter, subacute; their length even in preserved specimens often exceeds the height, or the transverse breadth of the body; the inner ones are larger and stouter; the outermost are much smaller, but long and slender, or almost filiform.

The color of the column varies from pale salmon to deep salmon and brownish orange, corresponding, in all cases, very closely with the color of the *Acanella* on which it is found. Tentacles usually darker than the body, often orange or orange-brown, sometimes light salmon, but frequently dark purplish brown, with paler tips. Disk similar to the tentacles, usually salmon radially streaked with brown; mouth large, often everted, frequently brown.

The larger examples have the longer diameter of the body above the base, 20 to 25 mm.; transverse diameter, 12 to 15 mm.; height, 10 to 15 mm.; length of tentacles, 10 to 15 mm.

The following specimens were dredged by the Blake in 1880: —

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
306	524	41° 32′ 50″	65° 55′	Several, on *Acanella*.
307	980	41° 29′ 45″	65° 75′ 10″	" "
308	1242	41° 24′ 45″	65° 35′ 30″	" "
309	304	40° 11′ 40″	68° 22′	" "
310	260	39° 59′ 16″	70° 18′ 30″	" "
312	466	39° 50′ 45″	70° 11′	" "

This species has also been dredged at numerous stations, in 219 to 506 fathoms, off Martha's Vineyard, by the U. S. Fish Commission, often in large numbers, on *Acanella*, which is common there.

It has also often been brought in by the Gloucester fishermen, since 1878, from many localities on the deep fishing banks, off Nova Scotia, and from the Grand Bank. A similar species, possibly identical, occurs on deep-water gorgonians dredged by the Blake among the Antilles.

Sagartia spongicola Verrill, sp. nov.

Plate VI. Fig. 3.

A small, rather cylindrical, smooth, rosy or flesh-colored species, with a moderate number of tentacles, which are not very long.

Column, in extension, higher than broad, round, usually nearly cylindrical, but frequently changing in form. Base small, often rather broader than the column, flat, or clasping sponges, hydroids, etc. Tentacles not very numerous, arranged in two, three, or more rows, close to the margin, leaving a large part of the disk bare; they are rather small, a little stout, not very acute, variously curled. Acontia have not been seen ejected, but there are a few small, pit-like openings on the sides, which appear to be pores (cinclidæ). Some specimens show small verrucæ near the summit. The internal lamellæ show as white lines through the sides of the body.

Color of the body and disk pale pink, light rosy, or pale flesh-color, varying to salmon-color, translucent. Tentacles often darker colored, salmon, light orange to orange-brown, commonly with a flake-white ring or streak near the tip. The color is often nearly uniform throughout.

Diameter 10 to 20 mm. ; height 15 to 25 mm.

This species has been taken in large numbers, on hard sandy bottoms, among and on sponges and worm-tubes, in 72 to 158 fathoms, at a number of localities, off Martha's Vineyard and off Delaware Bay, by the U. S. Fish Commission steamer Fish Hawk, in 1880, 1881, and 1882. It was not obtained by the Blake.

Synanthus mirabilis Verrill.

Synanthus mirabilis Verrill, Amer. Jour. Sci., XVII., 1879, p. 474.

Plate VI. Fig. 9.

This is a small actinian, which grows parasitically on the dead axis of *Paramuricea grandis* and other gorgonians. In some cases it is so closely grouped as to completely cover the surface of several of the larger branches, or even of the entire coral. The base of each individual expands widely, and closely clasps the branch, often entirely surrounding it, the opposite lobes coalescing when they meet ; the basal membranes of adjacent individuals also unite where they meet, and in this way entirely conceal the gorgonian axis. In alcoholic specimens most of the individuals are contracted into rounded verrucæ, with the tentacles entirely concealed, but some are still expanded ; in these the tentacles are contracted into a short, stout, blunt shape, and are arranged in two alternating circles of about twelve each, with indications of another outer circle of much smaller ones. Mouth small, elliptical. Surface of the body usually smooth, sometimes wrinkled, or having the appearance of low, inconspicuous verrucæ. The basal membrane shows distinct, divergent, radiating lines, corresponding to the internal lamellæ, and these lines are also frequently visible on the column itself. Diameter of the polyps, in alcohol, mostly from 2 to 4 mm.

When this genus was originally constituted, I supposed that the close union of the polyps, at their bases, was due to basal budding. Possibly that may be the case, to some extent, but the later and better preserved specimens indicate that it is due to coalescence.

The specimens originally described were from off Nova Scotia, in 200 to 300 fathoms, on *Paragorgia*, *Primnoa*, etc., but were poorly preserved ; possibly they may be distinct from those described above.

Station 317, in 333 fathoms, N. Lat. 31° 37′, W. Long. 78° 18′ 35″, Blake Expedition, 1880.

Urticina perdix Verrill.

Urticina perdix Verrill, Amer. Jour. Sci., XXIII., 1882, p. 223.

Plate VII. Figs. 1, 1 a.

This is a very handsome and large species, which sometimes expands to a breadth of 200 to 250 mm. (8 to 10 inches) across the tentacles. More frequently the expanse is 125 to 150 mm., with the body 75 to 100 mm. high and broad. The body is very contractile and changeable in form.

It lives well in aquaria. Several specimens were kept alive all summer, at Wood's Holl, in 1881 and 1882.

Color: column curiously mottled and reticulated with soft yellowish brown, varying from a pale tint to deep orange-brown; the ground color is pale buff, and the two colors alternate in transverse bands, the darker bands usually wider below, and often zigzag, or even broken up into squarish patches, while brown lines often cross the pale bands, giving an irregularly checkered pattern. These bands and spots are usually finer and more crowded above; disk usually pale yellowish olive, sometimes purplish, more brownish near the mouth, with faint alternating radii of lighter and darker tints; lips chocolate-brown, or red-brown; tentacles similar to disk, but paler, with two or three broad and ill-defined bands of brownish or purplish, the one near the tip faint, the basal one broader on the sides.

This was dredged several times by the U. S. Fish Commission, in 1880 to 1882, in the warm belt, off Martha's Vineyard, in 61 to 115 fathoms. It has not yet been taken, except in this region. It was not obtained by the Blake.

Urticina consors Verrill.

Urticina consors Verrill, Amer. Jour. Sci., XXIII., 1882, p. 225.

Plate VIII. Fig. 4.

A delicately colored species, with a soft, smooth integument. Column elongated in expansion; above, occasionally showing a few warts and longitudinal plications; margin simple. Tentacles numerous, in about four circles, crowded toward the margin; they are rather short and stout, tapered, acute, the outer ones much smaller. Mouth with strong, whitish, gonidial grooves at both ends, and about ten lobes on each side, separated by darker grooves. Color of body nearly uniform salmon, or rosy; tentacles a paler shade of the same, the outer ones with a flake-white blotch at the base, outside; disk pale salmon, with a pale bluish tint, and with flake-white radii, forking at the tentacles; mouth bright orange inside, with lines of reddish brown on the lips. Height, about 2 inches; diameter, 1.5 inches.

This species was taken in small numbers, off Martha's Vineyard, in 160 to 312 fathoms, 1880 to 1882.

All the specimens obtained were on the backs of a brilliantly colored species

of hermit-crab (*Sympagurus pictus* Smith), remarkable for large bright red patches on the basal part of its legs.

This species may not be a true *Urticina*. It resembles certain species of *Sagartia*, but no acontia were observed.

Actinauge Verrill, gen. nov.

Type, *A. nodosa,* formerly *Urticina nodosa* (Müller) Verrill.

Large actinians, with the tentacles and upper part of the body capable of involution. Integument of body of two kinds; that of the lower part is firm, thick, and more or less coriaceous or parchment-like, with persistent, solid warts or tubercles, usually in vertical rows, and sometimes partially covered with a thin, chitinous epidermal coating; that of the upper part of the body forms a marginal, brighter-colored band, below the tentacles, where it is soft and lubricous, secreting mucus abundantly, and rising into longitudinal ridges, crests, or oblong tubercles, which run to and unite with the bases of all the tentacles. The basal disk may be broad and flat, adherent, or it may be bulbous, clasping mud, or it may ensheathe the branches of Gorgoniæ, etc. Tentacles long and large, contractile. Lips with large folds and gonidial grooves.

This genus, like *Actinernus*, has marginal prolongations of the wall, running to and uniting with the outer bases of all the tentacles, but in *Actinernus* there is no specialized submarginal zone, and the body is not verrucose.

It is also closely allied to *Urticina* Ehr. (*Tealia* Gosse), of which the type is *U. crassicornis.* But the latter has the integument soft and lubricous over the whole body, and there is no marked specialization of the submarginal zone; the tubercles, when present, are small, not much thickened, and of the nature of true suckers for attaching foreign substances; and when not in use may so contract as to disappear entirely; the submarginal zone is nearly smooth, with a definite upper margin, and there are no vertical ridges running in on the disk to join the bases of the tentacles, as in this genus and *Actinernus.*

Actinauge nodosa (Fabr.) Verrill.

Actinia nodosa O. Fabricius, Fauna Grönlandica, 1780, p. 350.
? *Actinia digitata* (*pars*) Müller (? *non* Gosse).
Urticina nodosa Verrill, Amer. Jour Sci., VI., 1873, p. 440; VII., 1874, pp. 413, 500, pl. 7, fig. 7; XXIII., 1882, pp. 224, 315.
S. I. Simth & O. Harger, Trans. Com. Acad., III., 1874, pp. 11, 54.

Plate VI. Figs. 6, 7, 8, 8 a.

This large species is very abundant in deep water, along our coast, and northward to the Grand Banks.

It varies greatly in appearance, especially when contracted in alcohol. It is capable of contracting to a much greater extent than *U. callosa* and *Actinernus nobilis,* and when preserved, the upper part of the column is generally strongly

involuted and the tentacles concealed. In this condition the upper extremity is covered with convergent, strongly raised folds or crest-like ridges, larger and smaller ones irregularly alternating. These crests correspond in number to the tentacles, and run up somewhat on their outer bases; the larger ones, which correspond to the inner or primary tentacles, can be traced inward between the outer tentacles, until they run to and coalesce with the external basal portion of the inner ones. The upper portion of the column, covered by these ridges and crests, is strongly differentiated from the part below it, for its integument is soft and lubricous, and usually decidedly red or pink in color during life; this portion, in fact, like the tentacles, secretes an abundant mucus, which is strongly phosphorescent. A row of large rounded warts or tubercles, or a more or less marked, transverse, verrucose ridge separates this upper or submarginal zone from the general surface of the column, which is firmer, more or less verrucose, and generally wholly or partly covered with a dirty brownish, somewhat chitinous, tough and firmly adherent coating, which is strongly wrinkled in contracted specimens, and sometimes has hydroids, bryozoa, and even such shells as *Anomia* adhering to its surface. This covering is often partially, and sometimes wholly wanting, especially in very large examples. It often persists on the larger upper verrucæ, even when absent elsewhere, and in some rather exceptional specimens it is much thickened on these warts, or even forms for them hard conical tips, sometimes affecting thus only the uppermost row, but at other times several series of them.

The most common form (Fig. 6) in expansion has the body more or less cylindrical, varying to hour-glass shape. The base may be broad and flat, often much broader than the body, and adherent to stones and shells; it may closely clasp cylindrical worm-tubes, branches of gorgoniæ, etc.;* or it may be deeply concave and bulbous, and enclose a mass of sand and mud.† Specimens with these different styles of base may all occur in the same locality, without other corresponding differences.

The column is covered with hard, prominent, and persistent verrucæ, arranged in pretty regular vertical and transverse rows, the upper ones becoming larger and more prominent, often with a hard, sharp tip, the lower ones gradually diminishing. At a short distance below the upper edge there is a transverse ridge, or row of large tubercles, above which the character of the tubercles and of the integument abruptly changes, the rounded verrucæ being replaced by longitudinal ridges and crests, alternately larger and smaller. In other cases the verrucæ become nearly obsolete below the middle, or are indicated only by longitudinal and transverse wrinkles. In very large examples the

* This habit is still more common with several other species from the same localities. Among these are *Actinauge nexilis* V., *Sagartia abyssicola*, *S. Acanellæ* V., etc.

† These enclosed masses of bottom often afford us accurate data as to the precise nature of the bottom sediments, with the relative proportions of mud, sand, &c. in their original condition, for this matter is clasped so tightly that no part can wash out.

lower part of the body is usually nearly smooth and naked, with a firm, cartilaginous texture, but higher up there will usually be some very large, low, rounded verrucæ or tubercles, on some of which the brownish chitinous or epidermal coating is usually retained.

The tentacles are not very large, moderately long and slender, changeable, with the tips either acute or obtuse; in large examples they are numerous, forming several rows.

The color of the body, in life, is usually white, dull pale red, flesh-color, or salmon, where it is not concealed by the dirty, dark brown epidermis; the verrucæ are often whitish or pink, while the wrinkles and grooves between them are dark brown or mud-color; the submarginal zone, which is 15 to 20 mm. or more broad in the larger examples, is bright red, orange-brown, or chocolate-brown; the color is often in stripes of darker and lighter tints. The tentacles are usually dark pink, salmon, orange or orange-brown, varying to dull red and chocolate-brown. Disk usually orange or reddish brown, or chocolate, with lighter and darker radii.

This species grows to a large size. Examples are often taken that are 80 to 100 mm. (4 inches) in diameter, and 100 to 150 mm. (6 inches) high. Ordinary adult specimens are 50 to 75 mm. broad, and 80 to 100 mm. high, with the larger tentacles about 15 to 20 mm. long.

Of the typical variety, a number of specimens were taken by the Blake, south of George's Bank and off Martha's Vineyard, at Stations 303, 309, 310, in 260 to 306 fathoms; at Station 332, off Cape Hatteras, in 263 fathoms; and at Station 336, off Delaware Bay, in 197 fathoms.

It has been taken by the U. S. Fish Commission at a large number of stations on the Gulf Stream Slope, off Martha's Vineyard, Nantucket, and Long Island, and off Chesapeake Bay, during 1880, 1881, and 1882, in 86 to 506 fathoms. In this region it is often very abundant and of large size, in 160 to 506 fathoms. The smaller ones mostly occur clasping the tubes of *Hyalinœcia;* the large ones generally enclose a ball of sand and mud, in the bulbous base. It has also been taken by the Fish Commission off Cape Cod, in 50 to 90 fathoms, 1879, 1882; Gulf of Maine, Massachusetts Bay, Casco Bay, Bay of Fundy, in 50 to 150 fathoms, 1872 to 1879; off George's Bank, in 430 fathoms, on the Bache, 1872; off Nova Scotia, in 50 to 110 fathoms, 1877.

The Gloucester fishermen have brought it in from a large number of localities, on all the fishing banks, from George's to the Grand Bank, in 30 to 300 fathoms. It is particularly common on the stony bottoms of Le Have Bank, Western Bank, and Banquereau, off Nova Scotia.

The description of this species by Fabricius, from Greenland examples, applies accurately to one of our commonest varieties. I have also received two examples from Denmark, through Dr. Chr. Lütken, of the Copenhagen Museum, which, so far as can be seen from the alcoholic specimens, agree perfectly with some of our less nodose varieties. These were sent as *Actinia digitata* Müller. But the *Actinia* (or *Tealia*) *digitata* of Gosse and several other European writers may be a distinct species.

Variety **coronata** nov.

Plate VI. Figs. 8, 8 a.

This variety is chiefly peculiar in having one or two of the upper transverse series of verrucæ much more prominent than usual, and tipped by a conical, often acute point of hard chitinous material, of the same nature as the coating over the general surface, but thicker and harder. The lower part of the column may be covered with low tessellated verrucæ, or it may be nearly smooth. The base, in nearly all the examples of this variety that I have seen, is flat and adherent. The few specimens of this kind in my possession are mostly less than an inch in diameter. They are mostly from deep water, 300 to 980 fathoms. Intermediate states between this and the normal form are not rare. From Station 307, in 980 fathoms, there is a peculiar specimen (Figs. 8, 8 a) of this variety, in which there is a single circle of twelve very prominent, sharp-pointed verrucæ around the retracted summit; the lower part of the column is irregularly wrinkled and covered with a tough and closely adherent dark brown epidermis.

Variety **tuberculosa** nov.

Plate VI. Fig. 7.

This is a remarkable form, perhaps a distinct species. The column is covered with large, distinct, irregularly scattered, round or hemispherical, solid tubercles, which are persistent. The upper retractile border has irregular, strong, longitudinal, unequal crests. The surface of the column is covered with a firm dark brown epidermis. The base is broad and adherent to stones, lumps of mud, etc. The tubercles in alcoholic specimens are generally white, the surface between dark brown. Height in alcohol, 40 to 70 mm.; diameter, 25 to 45 mm.; diameter of tubercles, 5 to 10 mm.

I have never seen this variety alive, and therefore hesitate to separate it as a species, although it may very well prove to be distinct. I have seen no truly intermediate forms.

This variety has often been brought in from various localities, on the fishing banks off Nova Scotia, etc., by the fishermen of Gloucester, Mass., and presented to the U. S. Fish Commission by them. It has been dredged by the U. S. Fish Commission in the Gulf of Maine and off Nova Scotia. It was also sent to me by Mr. J. F. Whiteaves, who dredged several specimens of it in 1872, in the Gulf of St. Lawrence, off Anticosti Island, in 112 fathoms.

Actinauge longicornis Verrill.

Urticina longicornis Verrill, Amer. Jour. Sci., XXIII., March, 1882, p. 222.

Plate V. Figs. 1, 2.

This is a very large and beautiful species, remarkable for the large size, great length, and delicate coloration of its tentacles, and for the whitish or rosy

parchment-like character of the integument, below the well-defined submarginal zone. It is highly contractile. The tentacles are often carried erect and divergent, but the outer ones are often gracefully recurved ; they are submarginal, in four or five rows. Adult specimens are often 80 to 90 mm. in diameter of body, and 100 to 125 mm. high, exclusive of the tentacles, which may be 45 to 65 mm. long ; the breadth across the expanded tentacles may be 150 to 200 mm. (6 to 8 inches). The disk can expand very broadly.

Large specimens have vertical rows of persistent, but small and not very prominent verrucæ, below the submarginal zone, fading out toward the base. In some examples these verrucæ become more numerous, and more or less crowded along the rows, but they are never very large. The submarginal zone is soft and lubricous, and probably phosphorescent, though this was not determined by us. It is covered by longitudinal ridges and crests, alternately larger and smaller, and usually with darker and lighter stripes of orange-brown, or purplish brown color. The column below this is whitish or pale pink.

The long, tapering, acute tentacles are translucent, usually delicate pink or rose-color, and sometimes light purplish brown, usually with an ill-defined whitish ring at the base, and pale tips. The disk is usually whitish or pale rosy pink, and has broad radii of deep rose-red, or sometimes dark purplish brown, running from near the mouth to and between the bases of the tentacles, four of them usually passing between each pair of inner tentacles. Lips orange-brown or reddish, with deeper brown stripes on the large lateral folds ; the large gonidial grooves are paler.

The basal disk of the large specimens is almost always deeply concave, or bulbous, clasping and almost entirely enclosing a large mass of sand, etc. Young specimens are often attached by the clasping base to worm-tubes, and stems of *Tubularia indivisa*, etc. In these cases the edges of the disk wrap around and unite in a fine close suture on the opposite side of the support, thus forming a closed sheath, which may extend for some distance along the enclosed object, and when there are several specimens near together the edges of their bases may also unite continuously by similar sutures.

A strongly contracted specimen, of moderate size, apparently of this species, was taken by the Blake at Station 327, in 178 fathoms, off Beaufort, N. C., N. Lat. 34° 0′ 30″, W. Long. 76° 10′ 30″. The upper part of this is densely covered with small prominent verrucæ ; the lower part, with small scattered warts ; the integument is firm and somewhat leathery, or parchment-like, but very flexible and not very thick.

It has been taken by the U. S. Fish Commission steamer Fish Hawk, in 1880, 1881, and 1882, at many stations off Martha's Vineyard, in 100 to 325 fathoms. Many young ones were also taken off Delaware Bay, in 130 fathoms, adhering to hydroids, worm-tubes, sponges, etc., and often united by their bases into curious clusters.

Actinauge longicornis, var. Caribæa Verrill, nov.

Grows to very large size. One of the largest has the base clasped around a bundle of large silicious sponge spicules, like those of *Hyalonema*. This in alcohol has the body four inches in breadth; the base along the sponge spicula is six inches. Other large specimens hold globigerina and pteropod ooze in the bulbous base. The young mostly clasp branches and stems of *Gorgoniæ*, the basal edges uniting in a firm suture even when very small.

It resembles, when in alcohol, certain specimens of *longicornis*. It has a similar thick, parchment-like, white, naked integument, which is more or less reticulated by wrinkles, leaving slightly marked squarish elevations, on the middle of which there is often a small round wart.

Rather small, smooth, rounded, persistent verrucæ are sparingly distributed over the surface, above; they are arranged in longitudinal rows, and become smaller and more remote below, fading out above the base; some of the uppermost are often surmounted by a small, central, dark brown patch of a chitinous epidermal coating. The submarginal zone is crossed by numerous elevated ridges, which run to and join the bases of the tentacles, as in the typical form; but in most of the specimens dissected, they become larger and more swollen next the tentacles, and run far up their outer sides, so as to cause their bases to be more swollen than in the similarly preserved typical specimens, but these differences may be due largely to differing states of contraction. The tentacles seem to be fewer, relatively larger and longer, and more concentrated toward the margin, but of this it is not possible to judge accurately from alcoholic specimens.

Traces of orange-brown color remain, on some specimens, as a brown ring defining the lower edge of the submarginal zone, and as median stripes on the longitudinal ridges of this zone, and on their continuations on the outer bases of the tentacles.

The following specimens were dredged by the Blake, 1878–80.

Station.	Fathoms.	Locality.	Specimens.
1878–79.			
260	291	Off Grenada	1 large, on sponge spicules.
269	124	Off St. Vincent	2 j. on *Gorgonia*.
295	180	Off Barbados	2 l. clasping mud.
296	84	Off Barbados	1 l. " "
1880.			
XVIII.	600	N. Lat. 18° 20′ 30″, W. Long. 87° 16′ 40″	2 l. " "

Actinauge nexilis Verrill, sp. nov.

Plate VI. Figs. 4, 5.

Column low and broad in preserved specimens, with a firm integument, to which a brown epidermal film usually adheres, especially toward the base and

between the wrinkles of the upper parts. Surface of the upper half often more or less nodulous and wrinkled, becoming more so toward the margin, where the elevations become elongated ridges and crests. Base clasping the denuded axis of *Balticina* and other Pennatulidæ where these have been injured, most frequently on the upper end, but not uncommonly on other parts of the rachis, beyond which the polyps may be still alive. The lateral lobes of the base meet and coalesce around the axis, so as to form a tubular sheath, considerably beyond the breadth of the body. When two or more are crowded together, their basal disks unite where they come in contact, thus entirely covering the axis that supports them. Tentacles numerous, covering much of the disk, rather short, thick, tapering, but not seen in full extension.

Color of body usually pale salmon or flesh-color, with streaks of brown, in wrinkles; disk deep orange-brown, with darker brown radii; tentacles salmon-brown.

The following specimens were dredged by the Blake, in 1880.

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
310	260	39° 59′ 16″	70° 18′ 30″	4
327	178	34° 0′ 30″	76° 10′ 30″	1

It was dredged at several stations, off Martha's Vineyard, in 168 to 245 fathoms, on *Balticina*, by the U. S. Fish Commission, in 1881 and 1882.

Numerous specimens, from the various fishing banks off Newfoundland and Nova Scotia, have been brought in by the Gloucester fishermen. These are all on *Balticina*, and mostly from 200 to 300 fathoms.

Actinostola Verrill, gen. nov.

Type, *Urticina callosa* Verrill.

Size large, integument very thick, firm, leathery, lubricous, not very contractile. Column covered with large, irregular tubercles, not having the power of adhering to foreign substances; upper portion not essentially different from the rest, the surface being without specialized structures; margin indefinite, continuous with the bases of the smaller outer tentacles. Basal disk frequently smaller than the upper part of the column, usually concave and enclosing mud. Tentacles numerous, short, thick, more or less scattered over the disk, the inner ones much the largest, longitudinally sulcated, imperfectly contractile, not deciduous. Disk usually deeply concave; mouth large, with large, strongly lobed lips, and large gonidial grooves. The walls of the body are very thick, firm, leathery, and, although capable of considerable contraction longitudinally and transversely, they seem to be incapable of contracting sufficiently to withdraw the disk and tentacles; when handled, the column frequently becomes collapsed and longitudinally folded, and frequently takes an hour-glass shape, the disk and tentacles remaining fully exposed, although the tentacles may be very much diminished in size.

This genus is allied to *Bolocera*, *Urticina*, and especially to *Actinauge*. From

the latter it differs in not having the upper portion of the column specialized and different from that below, and also in being far less contractile. *Urticina* differs in not having the large non-adhesive tubercles, the warts, when present, being of the nature of adhesive suckers, and also in having the walls of the body and tentacles highly contractile. *Bolocera* differs in having the column smooth, or nearly so, with the tentacles long and easily deciduous. *Actinernus* differs in having the column smooth, and in having the upper margin divided into lobes which run up on the outer sides of the tentacles.

Actinostola callosa Verrill.

Urticina callosa Verrill, Amer. Jour. Sci., XXIII., March and April, 1882, pp. 224, 315.

Plate VII. Fig. 2.

This is, perhaps, the largest of the eight large species of actinians that inhabit these depths, though *A. nodosa*, *A. longicornis*, *U. perdix*, and *Bolocera Tuediæ* grow about as large. It is also remarkable for the great number of short, stout, usually blunt, striated tentacles. When full grown it has a remarkably firm, thick, leathery, but lubricous integument, and has but little power of contracting or rolling in the upper end. When handled it is apt to become irregularly flattened and collapsed, with broad longitudinal folds or wrinkles, while the tentacles and disk remain exposed, the very broad disk usually becomes deeply concave, and the tentacles contract in length and become blunt. The body usually narrows to the base, but may be hour-glass-shaped. The surface of the column is usually more or less covered with low, irregular, often flattish verrucæ, which become larger and more prominent, and sometimes form longitudial series or crests on the upper part, but fade out to mere wrinkles toward the base. There is no decided change in the character of the integument near the top, which is a conspicuous character in *A. nodosa* and *A. longicornis*.

The basal disk, in large specimens, is usually bulbous or deeply concave, firmly grasping a large mass of sand and mud, which it often nearly encloses. In the mud there are often numerous chitinous pellicles, which have been secreted and cast off from the base.

Large examples are often 150 to 180 mm. in height, with the expanded disk 200 to 250 mm. (8 to 10 inches) broad; the larger tentacles are about 25 mm. long, 5 to 6 mm. in diameter. Color generally salmon or orange, all parts often of nearly the same color; column almost always pale salmon or buff, varying to deep salmon or orange-red, with the tubercles paler; disk most often deep salmon, or generally of the same color as the body, but darker in shade, with paler radii; the large lateral lobes of the lips are like the disk, but darker, usually salmon or orange-brown, the large gonidial grooves whitish or pale yellow; tentacles usually plain deep salmon or orange-brown, with paler striæ or reticulations.

Young specimens, from 15 to 20 mm. in diameter and 20 to 30 mm. high, have been taken at several localities, off Martha's Vineyard, by the U. S. Fish Commission. These are usually more or less obconic, or pear-shaped, with the base narrow and the upper part of the body swollen. The base, in these, is generally concave, clasping mud or sand, but in several cases it is clasped around a worm-tube, or some similar object. Probably, when very young they may all have this habit of attaching themselves to some solid object, which is abandoned later. A small specimen, of similar character, was taken by the Blake, at Station 311, in 143 fathoms.

These young specimens have the tentacles not very numerous, in few rows, the inner ones much the longest, stout and pointed, the outer ones short and acute. The surface of the body is smooth, or nearly so, and is usually tinged with chocolate-brown or purplish; a darker brown ring surrounds the margin, at the base of the tentacles; the tentacles and disk are, usually, deep purplish brown. In these the integument is much thinner than in the adult, and more or less translucent.

Of this species large and typical specimens were obtained by the Blake, off George's Bank, at Station 303, and off Cape Fear, N. C., at Station 326, in 464 fathoms. These, as usual, enclose, in the deeply concave basal disk large masses of mud and sand. One of those from Station 326 was also adherent, by one edge of the disk, to worm-tubes.

The following specimens were dredged by the Blake, in 1880.

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
303	306	41° 34′ 30″	56° 54′ 30″	3 l., clasping sand and gravel.
326	464	33° 42′ 15″	76° 0′ 50″	2 l., 3 m., clasping mud and sand.
311	143	39° 59′ 30″	70° 12′ 0″	1 young, clasping stem.

Large specimens have been taken by the U. S. Fish Commission, often in large numbers, at many stations, off Martha's Vineyard and Nantucket, in 100 to 640 fathoms, 1880–82; off Cape Cod, in 55 to 90 fathoms, 1879, 1882; Gulf of Maine, in 50 to 150 fathoms, 1873, 1877, 1878; off Nova Scotia, 1877. It has also been taken on George's Bank and the various fishing banks off Nova Scotia, in 45 to 300 fathoms, by the Gloucester fishermen, in considerable numbers. Also from the Grand Bank of Newfoundland, in 100 to 150 fathoms.

Actinernus saginatus Verrill?

Actinernus saginatus Verrill, Amer. Jour. Sci., XXIII., 1882, p. 225.

A specimen in bad condition, perhaps of this species, was dredged at Station 326, off Cape Fear, N. C., N. Lat. 33° 42′ 15″, W. Long. 76° 0′ 50″, in 464 fathoms. Its form in contraction is low, broad obconic, with narrow base. Integument pale, cartilaginous. Tentacles numerous, small, slender, in two or three rows close to the margin. Disk broad, concave, and with the tenta-

cles deep chocolate-brown; a zone of the same color surrounds the margin below the tentacles.

The original specimen was taken by the U. S. Fish Commission, in 458 fathoms, off Martha's Vineyard, 1881.

Bolocera Tuediæ (JOHNST.) GOSSE.

Actinia Tuediæ JOHNSTON, Mag. Nat. Hist., V., p. 163, fig. 58.
Anthea Tuediæ JOHNSTON, British Zoöphytes, ed. 2, Vol. I. p. 242, fig. 53.
Bolocera Tuediæ GOSSE, Actinologia Britannica, 1860, p. 186, pl. 5, fig. 1.
VERRILL, Amer. Jour. Sci., V., 1873, pp. 5, 14; VI., 1873, p. 440; VII., 1874, pp. 413, 500.

This large species is easily distinguished by its smooth, lubricous, stout, dull red body, and by the very large, non-retractile tentacles. It often expands 150 to 255 mm. (6 to 10 inches) across the tentacles. The tentacles are often 50 to 75 mm. (2 to 3 inches) in length, and 10 to 15 mm. in diameter. The body is ordinarily 75 to 100 mm. (3 to 4 inches) in diameter and height.

When detached, which often happens, the tentacles retain their plumpness and fusiform shape, and are capable of contracting and expanding, so as to change their form, for some time, so that they resemble, and are sometimes mistaken for, entire living worms or holothurians.

The color is usually some shade of red, varying from pale flesh-color and pink to dark red; the body, in the paler examples, is often more or less tinged with salmon. The disk and tentacles generally correspond in color with the body, but are deeper in tint. When the body is flesh-color or light red, the tentacles and disk may be rose-red or dark red, while those specimens that have a dark red body may have the tentacles reddish brown or orange-brown.

Fine large specimens were dredged by the Blake, at Stations 309 and 310, in 304 and 260 fathoms, off Southern New England.

Detached tentacles were taken off George's Bank, at Station 303, in 306 fathoms, N. Lat. 41° 34′ 30″, W. Long. 65° 54′ 30″. One large and characteristic specimen was dredged at Station 326, off Cape Fear, N. C., in 464 fathoms.

The following specimens were dredged by the Blake, in 1880.

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
303	306	41° 34′ 30″	65° 54′ 30″	1 tentacle.
309	304	40° 11′ 40″	68° 22′	1 large.
310	260	39° 59′ 16″	70° 18′ 30″	1 "
326	464	33° 42 15″	76° 0′ 50″	1 "

It has been dredged at a large number of localities by the U. S. Fish Commission, since 1872, in the deeper parts of the Bay of Fundy; off Nova Scotia, in 50 to 100 fathoms; Gulf of Maine, in 50 to 150 fathoms; off Casco Bay, in 40 to 90 fathoms; Massachusetts Bay, in 40 to 52 fathoms; off Cape Cod, in 37 to 90 fathoms. Off Martha's Vineyard, on the Gulf Stream Slope, it has

been dredged, often in abundance and of large size, at many localities, in 160 to 640 fathoms, and sparingly in 65 to 125 fathoms, in 1880 to 1882.

A few specimens have been brought from the fishing banks, off Nova Scotia, by the Gloucester fishermen.

A closely related species (*B. Kerguelensis*) has been described by Studer from the Antarctic Ocean, off Kerguelen Island.

Epizoanthus Americanus VERRILL.

Zoanthus parasiticus VERRILL, Revision of Polyps, in Mem. Bost. Soc. Nat. Hist., I., 1864, p. 34 (*not* of Duch. & Mich., 1860).

Zoanthus Americanus VERRILL, *op. cit.*, 1864, p. 45; Proc. Bost. Soc. Nat. Hist., X., 1866, p. 335.

Gemmaria Americana VERRILL, American Naturalist, II., p. 9, fig. 42.

Epizoanthus Americanus VERRILL, Amer. Jour. Sci., II., 1871, p. 361; Dana, Corals and Coral Islands, ed. 1, 1872, p. 62, figs. 1, 2; Report on Invertebrata of Vineyard Sound, in Report of U. S. Fish Commission, I., 1873, pp. 446, 510, pl. 38, figs. 286, 287; Amer. Jour. Sci., VII., 1874, p. 413; XXIII., 1882, p. 316.

SMITH & HARGER, Trans. Conn. Acad., III., 1876, p. 55, pl. 8, fig. 2.

Epizoanthus papillosus GRAY, Proc. Zoöl. Soc. London, 1867, p. 237 (from Massachusetts Bay).

Plate VIII. Figs. 1, 6.

Two examples of a very singular variety (see Plate VIII. fig. 6) occurred at Station 332. These completely invest the tube of *Hyalinœcia*, and the polyps, which are of large size, form two regular opposite rows, of ten to twelve, on each side. A small incrusting variety occurred on *Paramuricea grandis*, at Station 305, almost completely covering several of the branches, their tips still remaining alive.

The following specimens were dredged by the Blake, in 1880.

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
303	306	41° 34′ 30″	65° 54′ 30″	3 on *Eupaguri*.
312	466	39° 50′ 45″	70° 11′	1 on stone.
316	229	32° 7′	78° 37′ 30″	1 on *Gorgonia*.
332	263	35° 45′ 30″	74° 48′	1, var., on *Hyalinœcia*.
333	65	35° 45′ 25″	74° 50′ 30″	Sev. on sand, shells, etc.
334	395	38° 20′ 30″	73° 26′ 40″	Sev. " " "
335	89	38° 22′ 25″	73° 33′ 40″	Sev. on sponges, etc.
336	197	38° 21′ 50″	73° 32′	1 on *Eupagurus*.
344	129	40° 1′	70° 58′	Sev. on *Eupaguri*.
325	71	40° 10′ 15″	71° 4′ 30″	1 on *Eupagurus*.

This is a very abundant species off our coast, in moderate depths. Many thousands of specimens have been taken off Nantucket, Martha's Vineyard,

Long Island, and off Chesapeake Bay, in 28 to 487 fathoms, by the U. S. Fish Commission, in 1871, 1880, 1881, and 1882. It is most abundant in 60 to 200 fathoms. In these localities the variety forming the abode of hermit-crabs (mostly *Eupagurus politus* Smith and *E. Kröyeri*) is very common, but the variety consisting usually of one to three polyps attached to a grain of sand is equally or even more common, while the varieties creeping over or incrusting sponges, shells, hydroids, tunicates, pebbles, etc., is often very abundant on the harder bottoms. It had previously been taken repeatedly by the U. S. Fish Commission, from 1871 to 1879, in the Gulf of Maine; Bay of Fundy, in 40 to 109 fathoms, 1872 ; off Nova Scotia, in 50 to 190 fathoms, 1877; off George's Bank, in 60 to 430 fathoms, 1872. Also from the Gulf of St. Lawrence, incrusting variety, on rocks (coll. Whiteaves).

The Gloucester fishermen often brought it in from the various fishing banks off Nova Scotia and Newfoundland, in 100 to 300 fathoms, 1878–80.

It was originally described by me from specimens of the form covering shells occupied by hermit-crabs (in this instance *Eupagurus pubescens*), from off New Jersey, in 30 fathoms, — Capt. Gedney.

An incrusting variety, apparently identical with the corresponding form of our species, has recently been described from the coast of Norway, under the name of *Zoanthus Norvegicus*, by Danielssen and Koren.

Epizoanthus paguriphilus Verrill.

Amer. Jour. Sci., XXIII., Feb. 1882, p. 137.

Plate VIII. Fig. 5.

Coral large, leathery, nearly smooth, translucent, incrusting spiral shells inhabited by *Parapagurus pilosimanus* Smith. The polyps are large, elongated, swollen at base, more or less cylindrical, sometimes conical, at other times expanded at the summit. The surface is throughout smooth, glabrous, naked, or with a slight, imperfect coat of fine mud; margin, just below the tentacles, softer, smoother, and lighter-colored than the rest. In the larger specimens there is usually a circle of seven to twelve polyps, arising from the outer margin of the coral, and directed radially outward and somewhat upward; along that portion of the margin which covers the front of the crab, the circle of polyps is interrupted for a considerable space; elsewhere the bases of the polyps are in contact, or nearly so. The entire upper surface of the coral is convex and destitute of polyps. Usually the apex of the univalve shell on which the colony started may be seen through the translucent integument near the postero-lateral border, on the left-hand side. Sometimes the shell has entirely disappeared by absorption. In all cases the coral extends far beyond the aperture of the original shell, in a spiral direction, itself forming the principal part of the habitation of the crab. The lower surface is also convex and smooth, and destitute of polyps, except one, which always stands below and in front of the aperture, in a position which would correspond to

the columella-lip of the spiral shell. The surface within the aperture, in contact with the crab, is coated with a smooth, brown film, not easily separable. The tentacles, in life, are rather slender in extension, very numerous, forming several distinct circles; in alcoholic specimens they are rather stout, short, tapered, subacute, nearly equal; in some cases they are entirely retracted, in others partially exposed. The color of the coral is translucent, bluish or purplish gray, or grayish brown. In fresh specimens the tentacles are pale orange or salmon, with lighter tips, and the polyps themselves partake more or less of salmon-color. In younger specimens the number of polyps is less in proportion to the age, but the arrangement is essentially the same.

Diameter of ordinary specimens, in alcohol, about 60 to 70 mm.; vertical thickness, 25 to 30 mm.; length of the polyps, 15 to 20 mm.; diameter in the middle, 10 to 12 mm.; at base, 12 to 18 mm. Some specimens considerably larger than this have been obtained.

This species was first taken by the Gloucester fishermen in deep water off the coast of Nova Scotia, in 1878, and by them presented to the U. S. Fish Commission. It has since been dredged by the U. S. Fish Commission off Martha's Vineyard, in 252 to 640 fathoms, 1880 to 1882 (Stations 880, 883, 893, 894, 938, 947, 994, 997, 998, 1028, 1029, 1122, 1124, 1140). At Station 947, in 312 fathoms, it was very abundant, several hundred having been taken at a single haul; at most of the other localities it was taken in small numbers.

The following specimens were dredged by the Blake, in 1880.

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
306	524	41° 32′ 50″	65° 55′ 0″	1
309	304	40° 11′ 40″	68° 22′ 0″	3 j.
322	362	33° 10′	76° 32′ 15″	4

Hitherto all the specimens of this species that have been taken have been occupied by *Parapagurus pilosimanus*, which has not been found by us in any other carcinœcium.

The young *Epizoanthus* evidently attaches itself to the shell when the crab is very small, for in most cases the enclosed shell is of small size, but by the growth of the polyp the aperture is enormously extended, so as amply to accommodate the crab after it has reached a large size. In the majority of specimens examined the original shell still remains, though usually entirely covered by the integument, but in some cases it seems to have been entirely dissolved and removed.

This species, although in habit like some of the varieties of *Epizoanthus Americanus*, is easily distinguished. It grows to a much larger size, with much larger polyps, and the surface is much smoother, more lubricous and translucent, and is destitute of the firmly adherent coating of sand always present on *E. Americanus;* moreover, the latter has a much less regular arrangement of the polyps, which usually stand out in radial directions, but at various angles.

MADREPORARIA.

Thecopsammia socialis Pourtalès.

Thecopsammia socialis Pourtalès, Bull. Mus. Comp. Zoöl., 1868, Vol. I. No. 7, p. 138; Illustrated Catalogue Mus. Comp. Zoöl., 1871, No. IV. Deep-Sea Corals, p. 44, pl. 2, figs. 9, 10.

Duncan, Madreporaria of the Porcupine Expedition, Trans. Zoöl. Soc. London, 1873, Vol. VIII. Part V.

Four specimens, all dead, were taken at Station 216, in 229 fathoms, N. Lat. 32° 7′, W. Long. 78° 37′ 30″, by the Blake, in 1880.

This species was taken by Mr. Pourtalès, on the Bache, off Florida, in 195 to 262 fathoms. It was also taken by the Porcupine Expedition, in 345 and 363 fathoms, north of Scotland.

Lophohelia prolifera Edw. & Haime.

Madrepora prolifera Pallas, Elench. Zoöph., 1766, p. 307.

Ellis & Solander, Zoöph., 1786, pl. 32, figs. 2, 3, 4, 5.

Lophohelia prolifera Edw. & Haime, British Fossil Corals, 1850, Intr., p. xx.; Hist. Nat. des Coralliaires, 1857, Vol. II. p. 117.

Duncan, Trans. Zoöl. Soc. London, 1873, Vol. VIII. Part V. p. 328.

Pourtalès, Deep-Sea Corals, 1871, p. 25, pl. 1, figs. 3, 4, 5; Bull. Mus. Comp. Zoöl., 1880, Vol. VI. p. 107.

Verrill, Amer. Jour. Sci., XVI., 1878, p. 377.

Moseley, Voyage of the Challenger, Report on the Corals, 1881, p. 178, pl. 6, figs. 7, 8.

Lophohelia affinis Pourtalès, Bull. Mus. Comp. Zoöl., I., 1868, p. 135.

A single dead specimen of this species was taken by the Blake, at Station 216, in 229 fathoms, N. Lat. 32° 7′, W. Long. 78° 37′ 30″.

Two specimens have been obtained by the Gloucester fishermen in deep water off the coast of Nova Scotia, and by them presented to the U. S. Fish Commission.

It has long been known from deep water off the coasts of Northern Europe, and from the Mediterranean. It was taken by Mr. Pourtalès on the Bache, off the coast of Florida, in 195 and 315 fathoms, and by the Blake, among the Antilles, in 291 and 874 fathoms. By the Challenger it was dredged among the West India Islands, in 390 and 450 fathoms; off St Paul's Rocks, in 100 fathoms; off Nightingale Island, in 100 to 150 fathoms. At the last-named locality fine specimens occurred in abundance. It was taken in large numbers by the Porcupine Expedition, off the European coasts. Studer records it from 50 fathoms, off Madeira.

The few specimens obtained from off our northern coasts are of the typical variety, and some are of large size, but all that I have seen were dead, though evidently recent.

Dasmosmilia Lymani Pourtalès.

Parasmilia Lymani Pourtalès, Illustrated Catalogue Mus. Comp. Zoöl., 1871, p. 20, pl. 6, figs. 8, 9, 10.
Verrill, Amer. Jour. Sci., XXIII., 1882, pp. 316, 406 (reproduction from fragments described).
Dasmosmilia Lymani Pourtalès, Bull. Mus. Comp. Zoöl., VI., 1880, p. 108.

This species was taken in considerable numbers by the U. S. Fish Commission Steamer Fish Hawk, in 57 fathoms, off Chesapeake Bay, 1880; off Martha's Vineyard, in 100 to 130 fathoms, 1881.

It was dredged by Mr. Pourtalès, while on the Bache, in 70 to 147 fathoms, off the Florida Reefs.

Flabellum Goodei Verrill.

Flabellum Goodei Verrill, Amer. Jour. Sci., XVI., 1878, p. 377; XXIII., 1882, pp. 313, 316, 407.

Plate V. Figs. 3, 4.

In life the color of the disk and tentacles is rich salmon; lips darker salmon, with stripes of dark purplish brown, or sometimes uniform madder-brown. The larger tentacles are stout, tapered, subacute.

This species has been taken in large numbers, but in most cases badly crushed, by the U. S. Fish Commission Steamer Fish Hawk, off Nantucket and Martha's Vineyard, in 219 to 780 fathoms, and off Chesapeake Bay, in 300 fathoms, 1880 to 1882.

It was first obtained by the Gloucester halibut fishermen in deep water off Newfoundland and Nova Scotia, in 180 to 400 fathoms, 1878. Several additional specimens, from that region, have since been presented by them to the U. S. Fish Commission.

This species is very closely related to *Flabellum alabastrum* Moseley,* dredged by the Challenger Expedition, off the Azores. The latter has been identified by Lindström (Actinology of the Atlantic Ocean, p. 12) with the *Ulocyathus arcticus* Sars, and the fossil *Phyllodes laciniatum* Philippi.

Our species grows to very large size; some specimens are 120 mm. long, 43 mm. broad, 80 mm. high.

* Proc. Royal Soc. London, 1876, p. 555; and Zoölogy of the Voyage of the Challenger, Part VII. Report on the Corals, 1881, p. 169, pl. 7, figs. 1–2 b, pl. 16, fig. 11.

Flabellum angulare Moseley.

Proc. Royal Soc. London, p. 556; Voyage of the Challenger, Part VII. Report on the Corals, 1881, p. 164, pl. 6, figs. 2, 2 a, 2 b.

This species was taken by the Challenger Expedition, off Nova Scotia, in 1250 fathoms.

Deltocyathus Italicus.

Deltocyathus Agassizii Pourtalès, Bull. Mus. Comp. Zoöl., 1867, Vol. I. p. 113; Illust. Cat. Mus. Comp. Zoöl., No. IV. Deep-Sea Corals, 1871, p. 15, pl. 2, figs. 1–5, pl. 5, figs. 9, 10; No. VIII. Hassler Exp., 1874, p. 35, pl. 6, fig. 11.
Verrill, Amer. Jour. Sci., VII., 1874, p. 410.
Lindström, Contr. to Actinology of the Atlantic Ocean, 1877, p. 10, pls. 1, 2, figs. 13–20.
Deltocyathus Italicus Duncan, Trans. Zoöl. Soc. London, Vol. VIII.
Pourtalès, Bull. Mus. Comp. Zoöl., 1880, Vol. VI. p. 101, pl. 1, figs. 1–8.
Moseley, Voyage of the Challenger, Deep-Sea Corals, 1881, p. 145 (woodcuts).

Two specimens of this species were taken by the U. S. Fish Commission, off Cape Cod, in 142 fathoms, Station 36, 1873. It has been taken in numerous localities off Florida and among the West India Islands, in 73 to 878 fathoms, by the Bache and the Blake. It was also taken by the Porcupine Expedition, off the coast of Europe; by the Josephine Expedition, off Villa Franca, Azores, and on Josephine Bank, in 110 to 600 fathoms; by the Challenger Expedition, off the Azores and Bermuda, in 1000 to 1075 fathoms, off Pernambuco, Brazil, in 675 fathoms, and in the South Pacific, in 2375 fathoms.

This is an exceedingly variable species. The living forms have been identified by Duncan, and by Pourtalès, in his last paper, with the fossil species, *Deltocyathus Italicus*, from the Italian tertiaries.

Bathyactis symmetrica Moseley.

Fungia symmetrica Pourtalès, Deep-Sea Corals, p. 46, pl. 7, figs. 5, 6; Hassler Expedition, 1874, p. 43;
Bathyactis symmetrica Moseley, Zoöl. Voyage Challenger, Part VII., 1881, p. 186, pl. 11, figs. 1–13, 1 a – 13 a.
Verrill, Amer. Jour. Sci., XIII., 1882, p. 313.
? *Fungiacyathus fragilis* M. Sars in G. O. Sars, Remarkable Forms of Animal Life, I., 1872, p. 58, pl. 5, figs. 24–32.

Numerous broken specimens of this very fragile coral were dredged by the U. S. Fish Commission, off Martha's Vineyard, at Stations 879, 880, 895, in

225–252 fathoms, 1880. Some of these specimens must have been at least 20 mm. in diameter. They agree in all respects with the larger specimens figured by Moseley.

This coral is remarkable for having a wider range, in depth and geographically, than any other known species. It was first taken by Pourtalès, off Florida, in 350 and 450 fathoms, on the Bache; and in 100 fathoms, off Barbados, on the Hassler. By the Challenger it was taken in the North Atlantic, off the Azores and off Bermuda, in 32 to 1075 fathoms; in the South Atlantic, in 1900 to 2650 fathoms; in the South Indian Ocean, in 1600 to 1950 fathoms; in the Malay Archipelago and West Pacific, in 360 to 2440 fathoms; east of Japan, in 2300 to 2900 fathoms; off Valparaiso, in 1375 fathoms. Studer also records it from the Pacific Ocean.

The *Fungiacyathus fragilis* of Sars closely resembles this coral, but according to the figures its septa are not united into groups, nor are there any transverse dissepiments nor trabiculæ in the four specimens described, although some of them were larger than many of the specimens of *Bathyactis*, in which these characters are well marked. A larger series of the arctic form may, however, serve to unite them hereafter.

July, 1883.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Distichoptilum gracile* V. Stem and lower part of rachis, seen edgewise. Enlarged $1\frac{1}{2}$ times.

" 1 a. The same. Terminal portion. Enlarged 2 diameters.

" 1 b. The same. Spicula: *c*, one of the larger oblong forms from a calicle; *d*, two from the stalk. Enlarged 75 diameters.

" 2. *Pennatula aculeata.* Side view of a medium-sized specimen. Natural size.

" 2 a. The same. Two of the polyps expanded. Drawn from a living example. Enlarged about 6 diameters.

" 3. *Balticina Finmarchica.* Front view of the lower part of the rachis of a small example, showing, below, the imperfectly developed polyps in nearly simple series. Enlarged 2 diameters.

" 3 a. The same. One of the mature polyps expanded. Drawn from a living example. Enlarged about 8 diameters.

" 4. *Funiculina armata* V. Portion of the middle of a large example. Natural size.

" 4 a. The same. One of the spicules of the calicles. Enlarged 75 diameters.

" 4 b. The same. Portion of a younger example. Natural size.

" 5. *Kophobelemnon scabrum* V. Front view of the type-specimen, in alcohol. Enlarged 2 diameters.

" 5 a. The same. Back side.

" 5 b. The same. Two of the spicula from the upper part of the stem: *d*, one of the longer and nearly smooth prismatic spicula; *e*, one of the smaller warted spicula. Enlarged 150 diameters.

" 5 c. The same. One of the larger, warted fusiform spicula, from the same part. Enlarged 250 diameters.

" 6. *Anthoptilum grandiflorum* V. Portion showing two rows of polyps from the middle region, side view; *a*, *a*, zoöids. Drawn from an alcoholic example. Natural size.

" 7, 8. *Anthomastus grandiflorus* V. Two small-sized examples, showing different forms of the peduncle and root-like lobes. Natural size.

" 9. The same. A very young example, with expanded polyps, natural size.

" 10. The same. A young example, with the polyps nearly retracted. Natural size.

" 10 a. The same. Spicula from the outer part of the cœnenchyma: *c*, one of the longest warty fusiform spicula; *d*, one of the small rough double-heads. Enlarged 150 diameters.

Fig. 10 b. The same. Spicula from the inner part of the cœnenchyma: *e*, one of the short rough spicula; *f*, one of the club-shaped forms; *g*, one of the larger fusiform spicula. Enlarged 150 diameters.

PLATE II.

Fig. 1. *Stenogorgia casta* V. Part of a specimen. Natural size.
" 1 a. The same. Part of a branch. Enlarged 4 diameters.
" 1 b. The same. Spicula: *c, d,* longer and shorter fusiform spicula; *e*, a slender fusiform spiculum from the polyps. Enlarged 75 diameters.
" 2. *Primnoa Pourtalesii* V. One of the branches. Natural size.
" 2 a. The same. Two of the calicles. Enlarged 24 diameters.
" 2 b, 2 c. The same. Two of the scales from the sides of the calicles. Enlarged 75 diameters.
" 2 d. One of the opercular scales. Enlarged 75 diameters.
" 2 e. One of the scales of the cœnenchyma. Enlarged 75 diameters.
" 3. *Eunicella gracilis* V. Part of a branch. Enlarged 4 diameters.
a, one of the club-shaped spicula of the external layer; *b*, one of the long fusiform spicula of the cœnenchyma, inner portion; *c*, one of the double-headed forms. Enlarged 150 diameters.
" 4. *Dasygorgia Agassizii* V. A segment of the stem with a branch. Enlarged 2 diameters.
" 4 a. The same. One of the calicles. Enlarged 24 diameters.
" 4 b. The same. Spicula. Enlarged 150 diameters.
" 5. *Dasygorgia spiculosa* V. One of the terminal calicles with the distal part of a branchlet showing the great development of the spicula. Enlarged 12 diameters.
" 6. *Chrysogorgia Desbonni* D. & M. One of the calicles from a West Indian example. Enlarged 12 diameters.
" 6 a, 6 b. The same. Two of the spicula of the cœnenchyma. Enlarged 75 diameters.
" 7. *Iridogorgia Pourtalesii* V. One of the calicles and segment of a branch from the proximal portion. Enlarged 6 diameters.
" 7 a. The same. Two of the largest spicula of the calicles. Enlarged 50 diameters.

PLATE III.

Figs. 1, 1 a, 1 b. *Acanthogorgia armata* V. Three branches, all from the same specimen, showing the extreme variations in the form of the calicles. Enlarged 4 diameters. From an alcoholic specimen.
" 2. The same. Terminal branches of a normal specimen. About one half natural size.
" 2 a. The same. One of the calicles, from a dried specimen. Enlarged 4 diameters.
" 2 b. The same. Spicula: *c, d, e,* spines from the margin and upper part of the calicles; *f, g,* two fusiform spicula from the cœnenchyma. Enlarged 22 diameters.

Fig. 3. *Paramuricea grandis* V. Part of a branch. Enlarged 4 diameters.

" 3 a. The same. Spicula: *c, d,* spinose spicula from the margin of the calicles; *i, j, k,* flattened irregular spicula from the cœnenchyma; *h,* one of the curved or bow-shaped spicula from the bases of the tentacles; *g,* one of the fusiform spicula from the stem of a tentacle. Enlarged 40 diameters.

" 3 b. The same. One of the spicula from the tentacles. Enlarged 75 diameters.

" 4. *Paramuricea borealis* V. Terminal branch and branchlet. Enlarged 2 diameters. From a dried specimen.

" 5. The same. One of the calicles from the original type-specimen (dry). Enlarged 8 diameters.

" 5 a. The same. Spicula: *c, d, e,* spinous spicula from around the margin of the calicles; *g,* one of the irregular flattened spicula from the calicles; *f,* one of the transverse, bow-shaped spicula from the bases of the tentacles. Enlarged 40 diameters.

" 5 a′. The same. Spicula from the cœnenchyma: *i,* one of the small warted spicula; *j, k, l,* irregular and bent forms. Enlarged 40 diameters.

" 6. *Gersemia longiflora* V. One of the branches. Natural size. From the alcoholic example.

" 6 a. The same. One of the calicles. Enlarged 4 diameters.

" 6 b. The same. Spicula: *c, d, e,* oblong and fusiform; *f, g,* compound forms.

PLATE IV.

Fig. 1. *Lepidisis caryophyllia* V. Lower portion of the stalk, with the root-like basal lobes. Natural size.

" 1 a. The same. Portion of the stem with three calicles, from an alcoholic specimen. Enlarged 4 diameters.

" 1 b. The same. Proximal end of one of the large spine-like spicula of the calicles. Enlarged 75 diameters.

" 1 b′. The same. Spicula of the calicles: *d,* one of the large marginal spines; *e,* a marginal or submarginal spine with the tip less projecting; *f,* one of the small lateral spicula; *g, h, i,* small spicula from the tentacles. Enlarged 22 diameters.

" 1 c. The same. Scale-like spicula of the cœnenchyma. Enlarged 75 diameters.

" 2. *Acanella Normani* V. Part of the denuded axis, to show the mode of branching. Natural size.

" 2 a. The same. Four calicles at the end of a branch, from life. Enlarged 4 diameters.

" 2 b. The same. Spicula: *c,* one of the long marginal spines of the calicles, but not of the largest size; *d, e,* smaller spicula found both in the calicles and cœnenchyma; *f,* one of those found in the tentacles. Enlarged 22 diameters.

" 3. *Ceratoisis ornata* V. Part of the denuded axis. Natural size.

" 3 a, 3 b. The same. Two calicles from different parts of a large alcoholic

specimen from off Nova Scotia, showing the extreme variation in form.

Fig. 3 c. The same. One of the large spine-like spicula (*e*) from the margins of the calicles. Enlarged 22 diameters.

" 3 d. The same. Spicula : *f, g*, fusiform spicula found in the calicles and cœnenchyma ; *h, k*, spicula with enlarged ends, from the calicles ; *i, j*, small spicula from the tentacles. Enlarged 22 diameters.

" 4. *Lepidisis longiflora* V. One of the calicles of an alcoholic specimen from the West Indies. Enlarged 8 diameters.

" 4 a. The same. Scale-like spicula of the cœnenchyma ; *b*, two of the larger ; *c*, two of the smaller forms. Enlarged 75 diameters.

" 5. *Acanella eburnea* (Pourt.) V. One of the calicles, from an alcoholic specimen. Enlarged 8 diameters. From a West Indian specimen.

" 6. *Anthothela grandiflora* (Sars) V. Two branches from a ramose alcoholic specimen, taken off Nova Scotia. Natural size.

" 6 a. The same. Spicula: *e, f*, rough fusiform spicula from the cœnenchyma ; *g, h*, from the calicles. Enlarged 75 diameters.

" 7. *Eunephthya Lütkeni* V. Branch of a specimen in alcohol, from off Nova Scotia. Enlarged 2 diameters.

" 7 a. The same. Spicula : *b*, one of the rough club-shaped spicula from the calicles ; *c, d*, rough fusiform spicula from the cœnenchyma. Enlarged 75 diameters.

PLATE V.

Fig. 1. *Actinauge longicornis* V. View of the expanded disk and tentacles, from life. One half natural size.

" 2. The same specimen. Side view in partial expansion. The dotted line shows the extent of the basal concavity. One half natural size.

Figures 1 and 2 are from one of the original type-specimens, dredged by the U. S. Fish Commission in 1880, and kept in an aquarium for several days.

" 3. *Flabellum Goodei* V. Side view of a dry and somewhat broken specimen from the fishing banks off Nova Scotia. From a photograph. Natural size.

" 4. The same. Top view of an alcohic specimen, dredged off Martha's Vineyard by the U. S. Fish Commission. Natural size.

PLATE VI.

Figs. 1 to 1 c. Three examples of *Sagartia abyssicola* V., attached to the tube (*g*) of *Hyalinœcia artifex* V., natural size ; *h*, head and anterior segments of the annelid protruded from the tube, side view ; *i*, the 32d and 33d segments of the same annelid, natural size ; *j*, caudal segments and cirri, enlarged 2 diameters ; *k*, under side of head and anterior seg-

ments of another specimen of the same annelid, natural size. These figures are mostly from alcoholic specimens, somewhat restored as to positions. From the collection of the U. S. Fish Commission.

Fig. 1 a. *Sagartia abyssicola.* Expanded.

" 1 b. The same. Partially contracted.

" 1 c. The same. Expanded and also showing the acontia (*a*) protruded from the pores (*cinclidæ*) in the sides of the body. From alcoholic specimens.

" 2. *Sagartia Acanellæ* V. Side view of a specimen covering the terminal part of a branchlet, *a*, *b*, of *Acanella.* Enlarged 2 diameters.

" 2 a. The same. Side view of a smaller, partially contracted specimen on the middle of a branchlet. Enlarged 1½ diameters. From alcoholic specimens.

" 3. *Sagartia spongicola.* Nearly vertical view of a specimen not fully expanded. Natural size, from life.

" 4. *Actinauge nexilis* V. Four contracted alcoholic specimens attached to and completely covering the distal portion of the axis of a mutilated *Balticina Finmarchica.* *a*, side view of the terminal one, showing how the basal membrane extends over the end of the axis of the *Balticina;* *d*, basal view, showing the suture by which the edges of the basal disk unite to clasp the axis. Natural size.

" 5. The same. Top view of another less contracted alcoholic example, from the tip of a mutilated *Balticina.* Natural size.

" 6. *Actinauge nodosa.* Side view of a partially contracted, medium-sized example of the commonest or normal form, but with a bulbous base, enclosing mud. From an alcoholic specimen. One half natural size.

" 7. The same, var. *tuberculosa* V. Side view of a moderate-sized example, contracted in alcohol. Natural size. This specimen was from the fishing banks, off Nova Scotia.

" 8. The same, var. *coronata* V. Side view of a contracted alcoholic specimen, from the Blake collection. Natural size.

" 8 a. The same specimen. Top view. Enlarged 2 diameters.

" 9. *Synanthus mirabilis* V. (?) Portion of the dead axis of *Paramuricea grandis* entirely covered by the confluent individuals of this actinian. Enlarged 2 diameters. From an alcoholic example.

PLATE VII.

Fig. 1. *Urticina perdix* V. Side view of an expanded specimen, of medium size, from life. One half natural size.

" 1 a. The same. Mouth and segment of disk, with tentacles, of a larger example, from life. Natural size. These drawings were made from the original type-specimens, dredged off Martha's Vineyard by the U. S. Fish Commission, and kept alive for several weeks in aquaria.

" 2. *Actinostola callosa* V. Side view of a medium-sized example, from life. One half natural size. From a specimen dredged by the U. S. Fish Commission.

PLATE VIII.

Fig. 1. *Epizoanthus Americanus* on *Eupagurus pubescens.* Natural size. From the Gulf of Maine, 1873.

" 2. *Adamsia sociabilis* V. on *Catapagurus Sparreri* A. M.-Edw. (= *Hemipagurus socialis* Smith), drawn from life. Side view in its natural position, enlarged 2 diameters, showing the basal chitinous pellicle from which the basal disk has partially withdrawn. In this example it had a fragment of *Dentalium* for a nucleus.

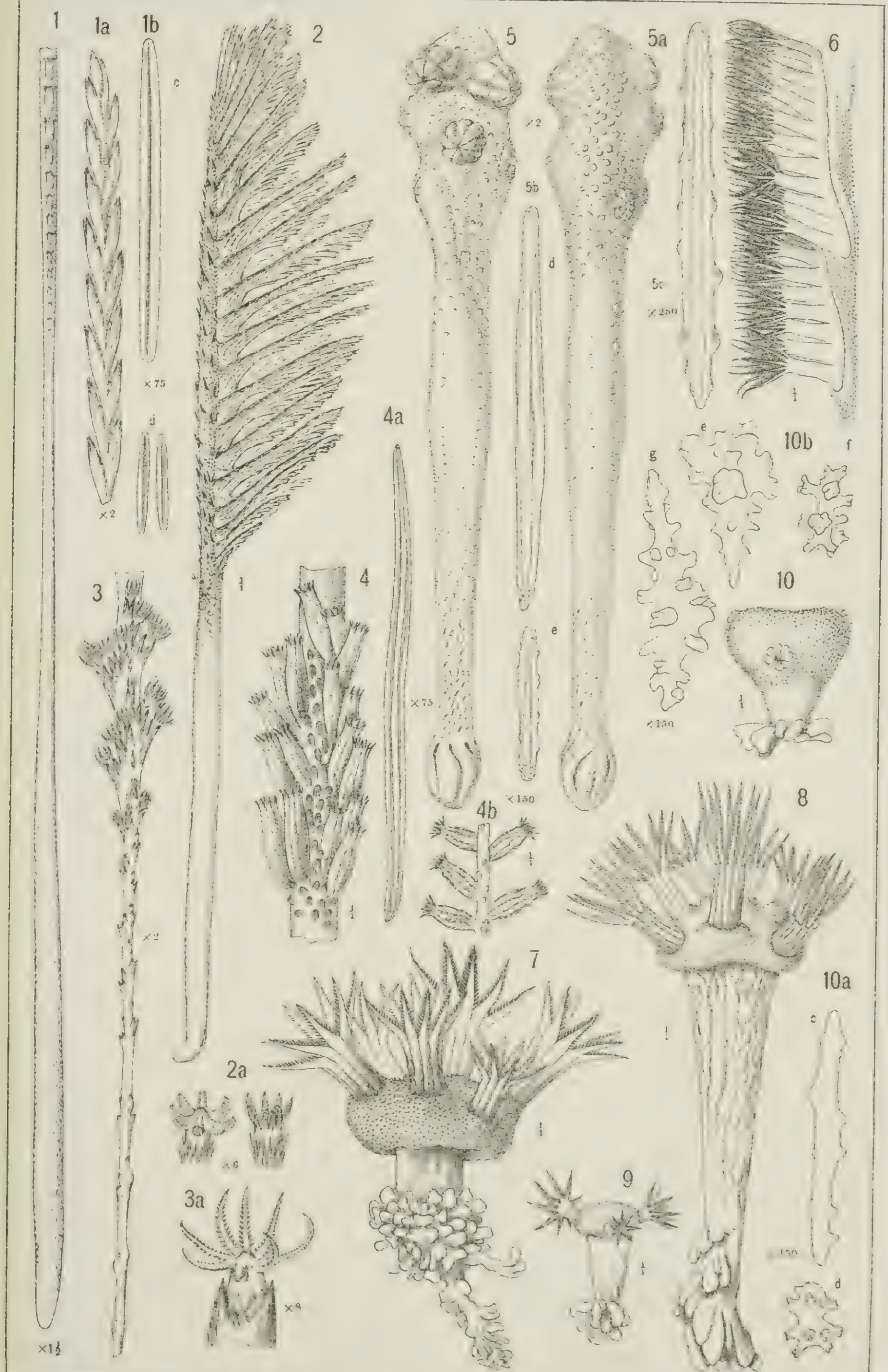
" 3. *Adamsia sociabilis* V., without the crab. Another example, seen in a posterior view, drawn from a living specimen, showing the chitinous basal secretion, which enclosed the crab, and had been partially uncovered by the contraction of the basal disk.

" 4. *Urticina consors* V. on *Sympagurus pictus* Smith. One half natural size. Drawn from the living specimens in natural positions.

" 5. *Epizoanthus paguriphilus* V., on *Parapagurus pilosimanus* Smith. Natural size. Drawn from an alcoholic specimen partially contracted.

" 6. *Epizoanthus Americanus* V., peculiar variety, on a tube of *Hyalinœcia artifex* V. Natural size.

Figures 2 to 5 are from specimens dredged off Martha's Vineyard by the U. S. Fish Commission, in 1880 and 1881. For the use of these and several other drawings of actinians made from life, I am indebted to the U. S. Fish Commission. All the drawings were made by Mr. J. H. Emerton.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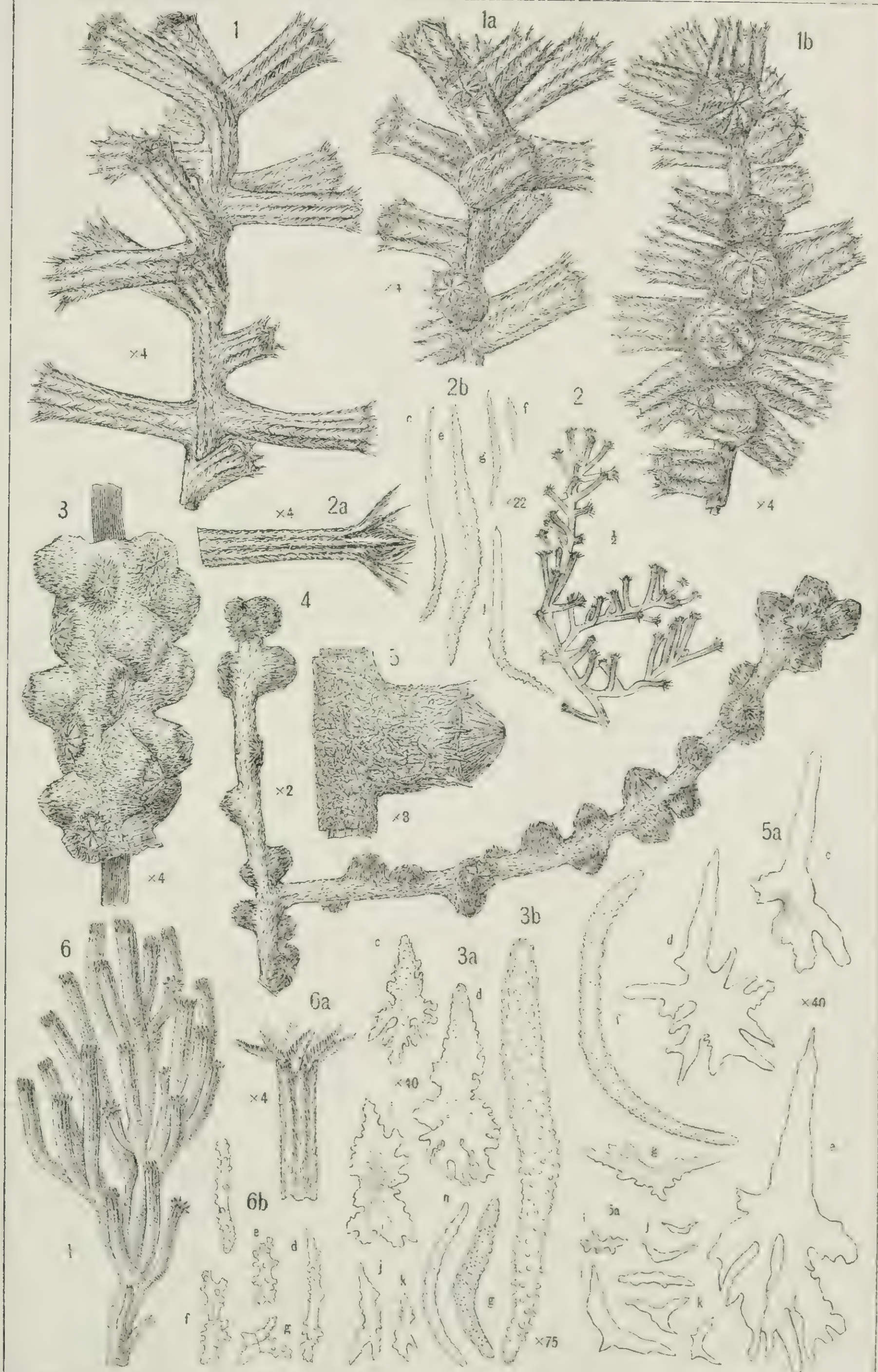
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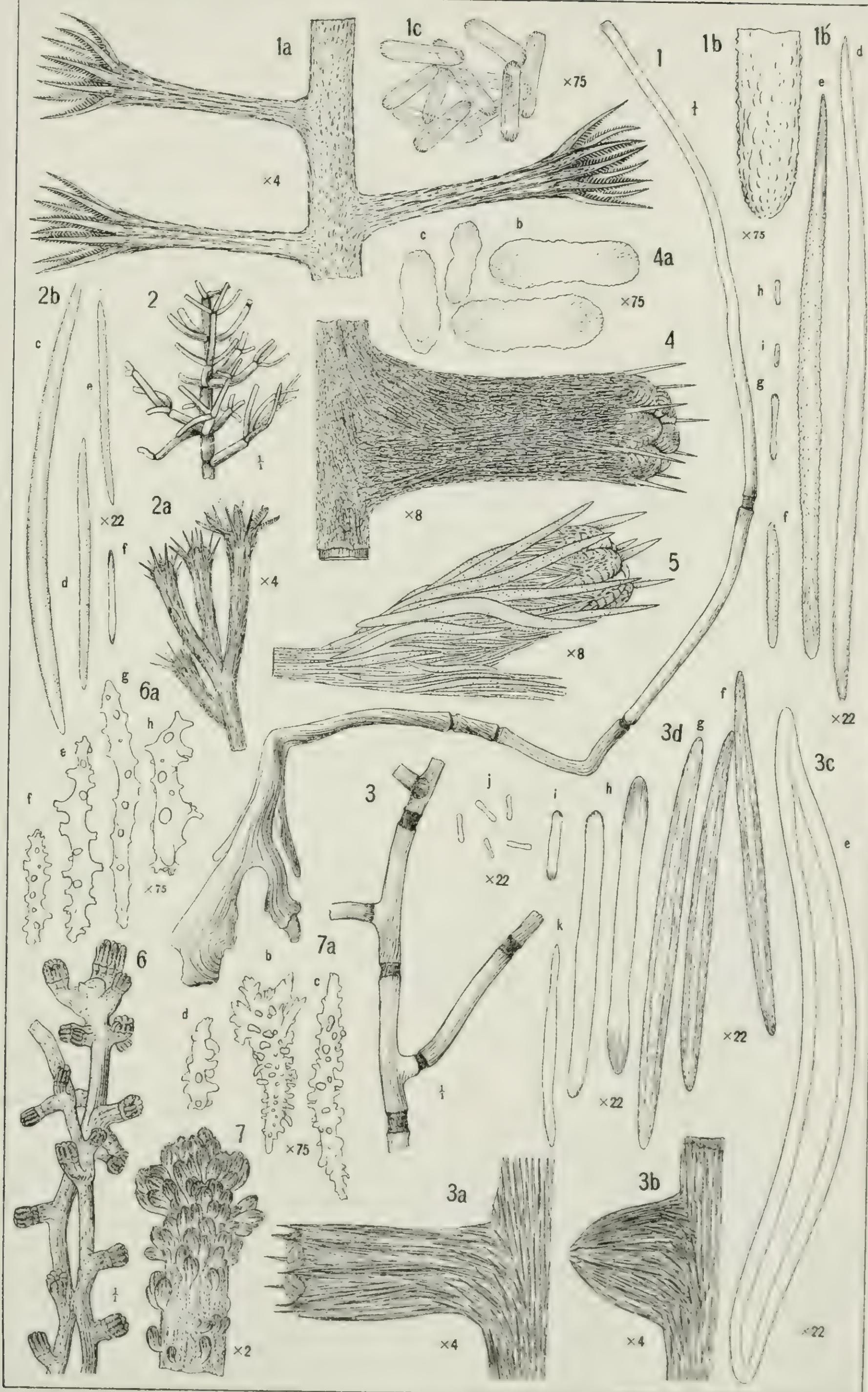

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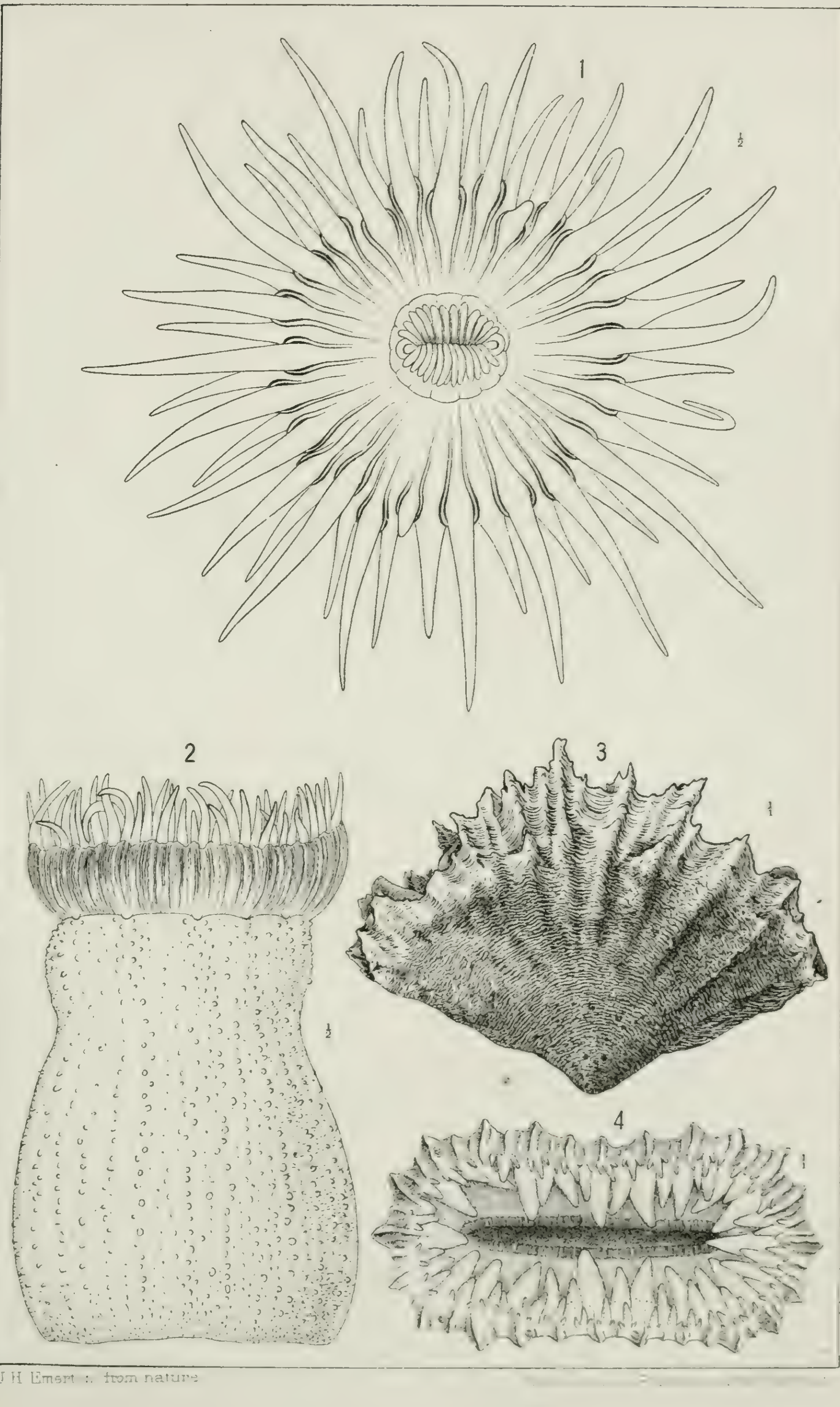

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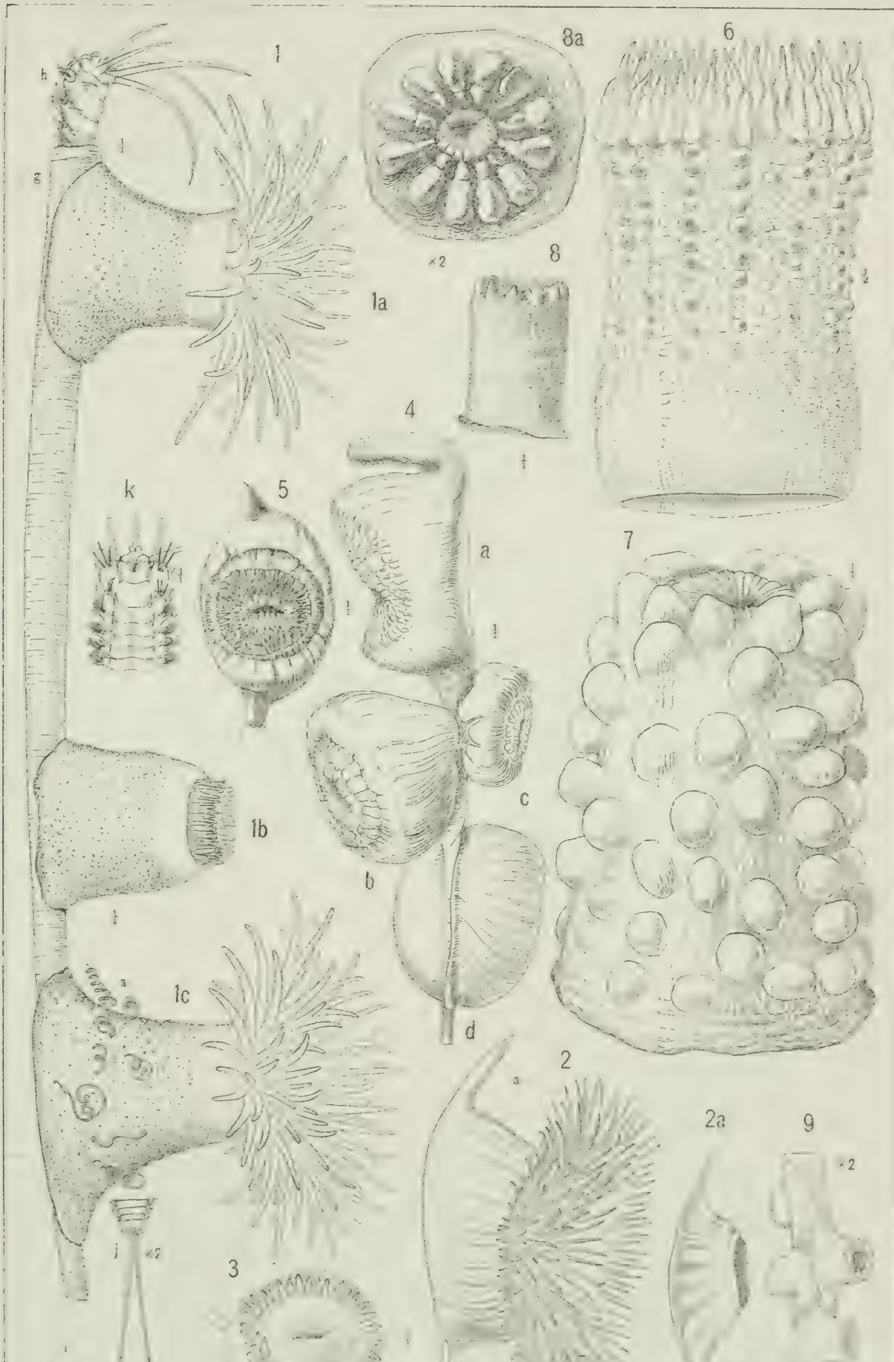
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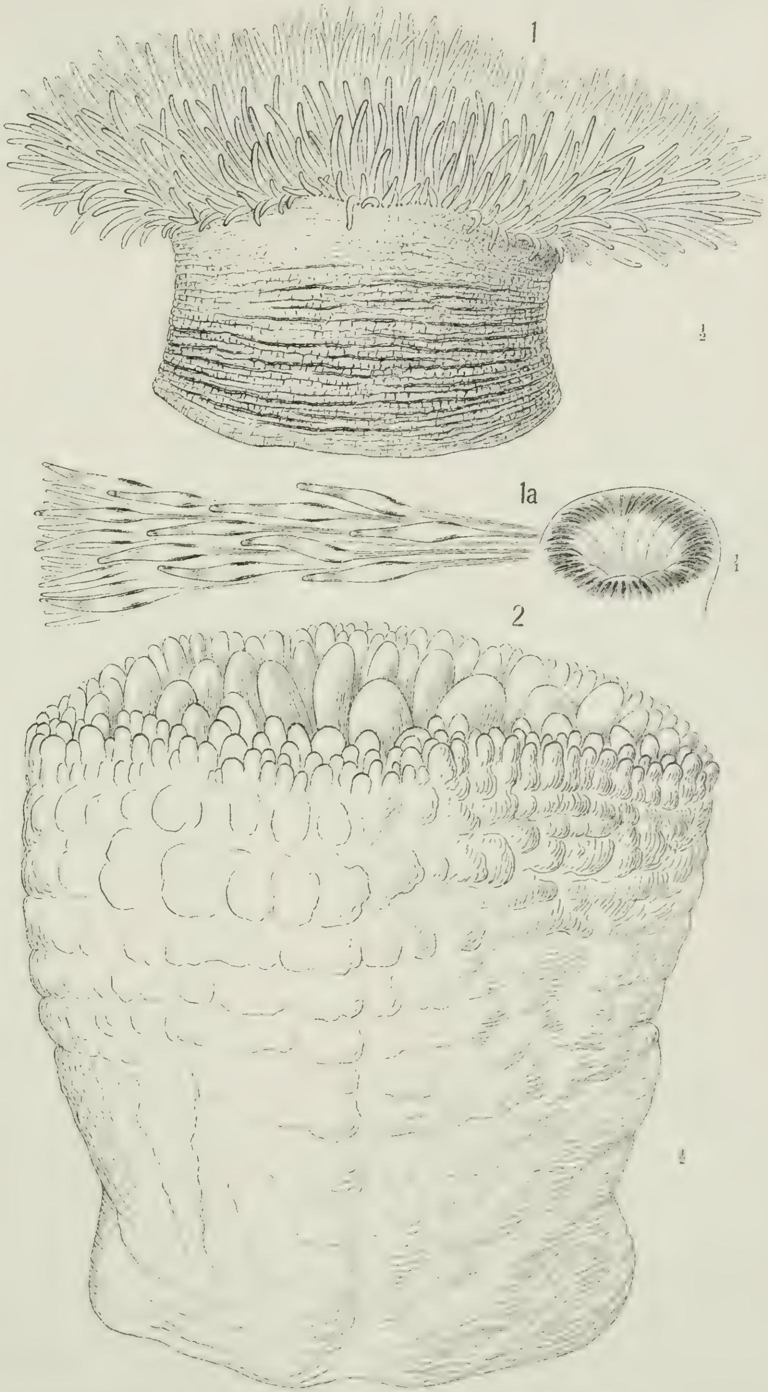
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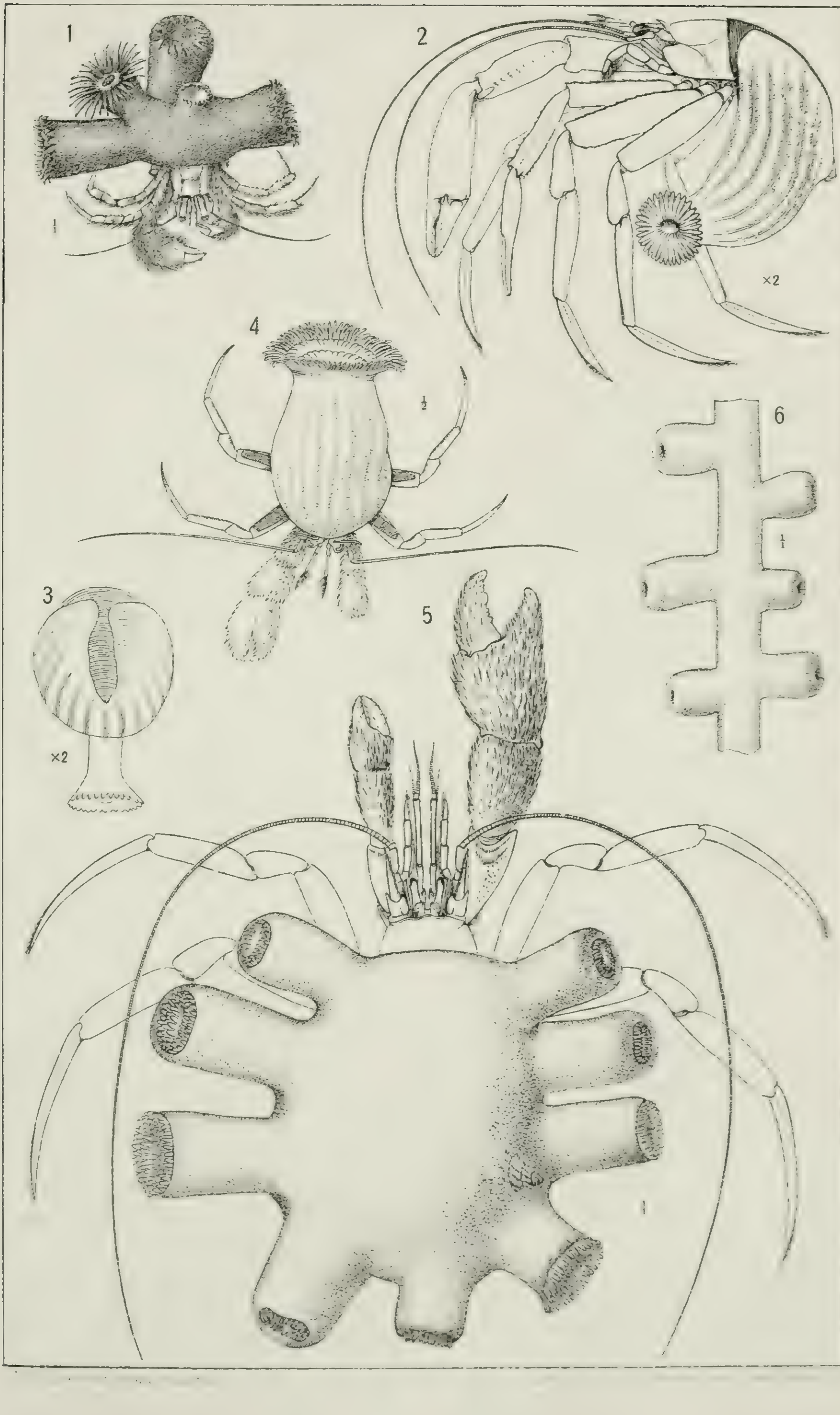
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No. 2.—*Reports on the Results of Dredging, under the Supervision of* ALEXANDER AGASSIZ, *along the Atlantic Coast of the United States, during the Summer of* 1880, *by the U. S. Coast Survey Steamer "Blake,"* COMMANDER J. R. BARTLETT, U. S. N., Commanding.

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XXII.

A Chapter in the History of the Gulf Stream. By ALEXANDER AGASSIZ.

THE soundings of the "Blake" during the dredging season of 1880 developed some striking features in the profile of the slope extending eastward from the shore along the Atlantic coast, south of Cape Hatteras to the northern extremity of Florida. The soundings previously taken in deep water between the northern extremity of the Bahamas and Cape Hatteras varied greatly, and but little reliance could be placed upon them. The few lines run in 1880 normal to the coast, and the line run parallel to the so-called axis of the Gulf Stream, showed the probable existence of an immense submarine plateau extending eastward from the Atlantic shores. Either the eastern edge of this plateau was not reached in 1880, or else the soundings indicated a very gradual slope from the shore to deep water along the whole coast line south of Cape Hatteras as far as the northern part of Florida.

Everywhere else along the Atlantic coast of the United States, north of Cape Hatteras and in the Gulf of Mexico, the continental line of one hundred fathoms is most plainly marked, forming the upper edge of the more or less abrupt descent leading into deep water with a regular inclination. Owing to the absence of this hundred-fathom line south of Cape Hatteras, it became an interesting problem to trace the exact profile of that part of the coast, and to extend it into deep water. The season of 1881 was spent by Commander Bartlett in the "Blake," under the direction of the Hon. Carlile P. Patterson, the late Superin-

tendent of the Coast Survey, in running a number of lines normal to the coast, south of Cape Hatteras and north of the Bahamas, and extending them into deep water. Commander Bartlett has sent his Report to Professor Hilgard, the Superintendent of the Coast Survey, who has kindly allowed me to make use of these results in connection with my present work on a general report of the dredging expeditions of the "Blake." The accompanying map has kindly been prepared for my use by the Superintendent of the Coast Survey.*

As was to a certain extent anticipated, the lines show the existence of an extensive plateau, of a triangular shape, reaching from the Bahamas to immediately south of Cape Hatteras, where this plateau gradually passes into the continental plateau, extending northward, which is limited by the 100 fathom line, and has a steep slope extending to deep water.

The eastern edge of this plateau is from 300 to 350 miles from the coast, and forms a gigantic submarine plateau, with an abrupt slope passing into deep water. For the sake of brevity I shall call this plateau the "Blake plateau." The eastern edge of the slope of the Blake plateau commences at an average depth of at least 400 fathoms, so that the general profile of the lines extending normally across the Blake plateau show a gradual incline from the shore to a depth of about 50 fathoms, then a somewhat abrupt slope to a depth of about 400 fathoms, then a very gradual descent to the edge of the sharp, steep slope forming the outer eastern edge of the Blake plateau, at a depth of nearly 600 fathoms.

It is interesting to speculate how this peculiar profile, so different from that of any other part of our coast, was formed. The explanation to my mind is comparatively simple. The present outer eastern edge of the Blake plateau, which is now at a depth of 600 fathoms, was at one time at a much higher level. In fact, I assume that this slope

* These lines have, during the season of 1882–83, been extended south of the Bahamas as far as Porto Rico. Under the direction of Professor Hilgard, the "Blake," in command of Lieutenant-Commander Browson, U. S. N., ran normals into deep water, showing that the great submarine Bahama plateau developed by Commander Bartlett commences slightly to the westward of Great Abaco, and extends thence northward, as is shown on the accompanying map. Lieutenant-Commander Browson showed further that to the south the eastern edge of the Bahama Bank extended but a short distance seaward parallel to the general line of the outer row of islands of the group, till it united with the great plateau upon which Porto Rico and the Caribbean Islands crop out, leaving probably one or two deep passages extending towards the old Bahama Channel north of San Domingo and Cuba, leading to the Windward Passage.

probably represents the remnant of the slope formed at the time when it began at the 100 fathom line, and that this trough with unequal sides has been worn away by the action of the Gulf Stream, wearing away the Blake plateau from a geological time which we can trace with a considerable degree of accuracy.

In other words, the old continental line extended at least 250 to 300 miles farther to the eastward, forming a huge plateau, the 100 fathom line of which extended to where the 600 fathom line now runs, and probably stretched so far south as to include the Bahamas and Cuba in this great submarine plateau. The elevation of the Blake plateau probably dates back to the end of the cretaceous period, the time when the plateau of Mexico was raised, thus cutting off whatever communication may have existed between the waters of the Atlantic and those of the Pacific, forming at the same time a number of islands, more or less extensive, in the range of the Larger and Lesser Antilles.

At that time, the Gulf Stream passing between Yucatan, then a submarine plateau of comparatively moderate depth, and Cuba, furrowed the deep channel, 1,000 fathoms or more, which now separates Yucatan from Cuba. The Gulf Stream then lost itself northward in the great Mississippi Bay, and extended fan-shaped in part over the submarine plateau of Florida. It brought, however, an accession of materials by the deposition of which the plateaus of Yucatan and of Florida were gradually built up, and which also supplied food to the innumerable marine animals whose existence is proved by the geological structure of the very plateau upon which they must have lived. The Gulf Stream thus contracted its own boundaries, and was forced into the narrower channel it had constructed between Yucatan and Cuba. As a consequence, it cut an ever deepening trough, and in proportion as Florida rose from the sea it was also compelled to find an outlet for the mass of water by which the Florida peninsula had been covered. It naturally followed the track of least resistance, and forced its way up hill over the lowest part of the plateau, the southern point of Florida, through the then comparatively shallow passage of the Straits of Bemini, which the Gulf Stream must have deepened by degrees as Florida was rising.

The mass of water which in the early part of the tertiary period forced its way north partly up the Mississippi, and east over the peninsula of Florida, was little by little confined to the single channel of the Straits of Bemini, and the whole mass of the Gulf Stream then flowed

northward over the shallow plateau (the Blake plateau) extending north of the Bahamas to Cape Hatteras. It is this part of the Blake plateau which, if I am right in tracing its past history, has been worn away by the unceasing flow of the Gulf Stream.

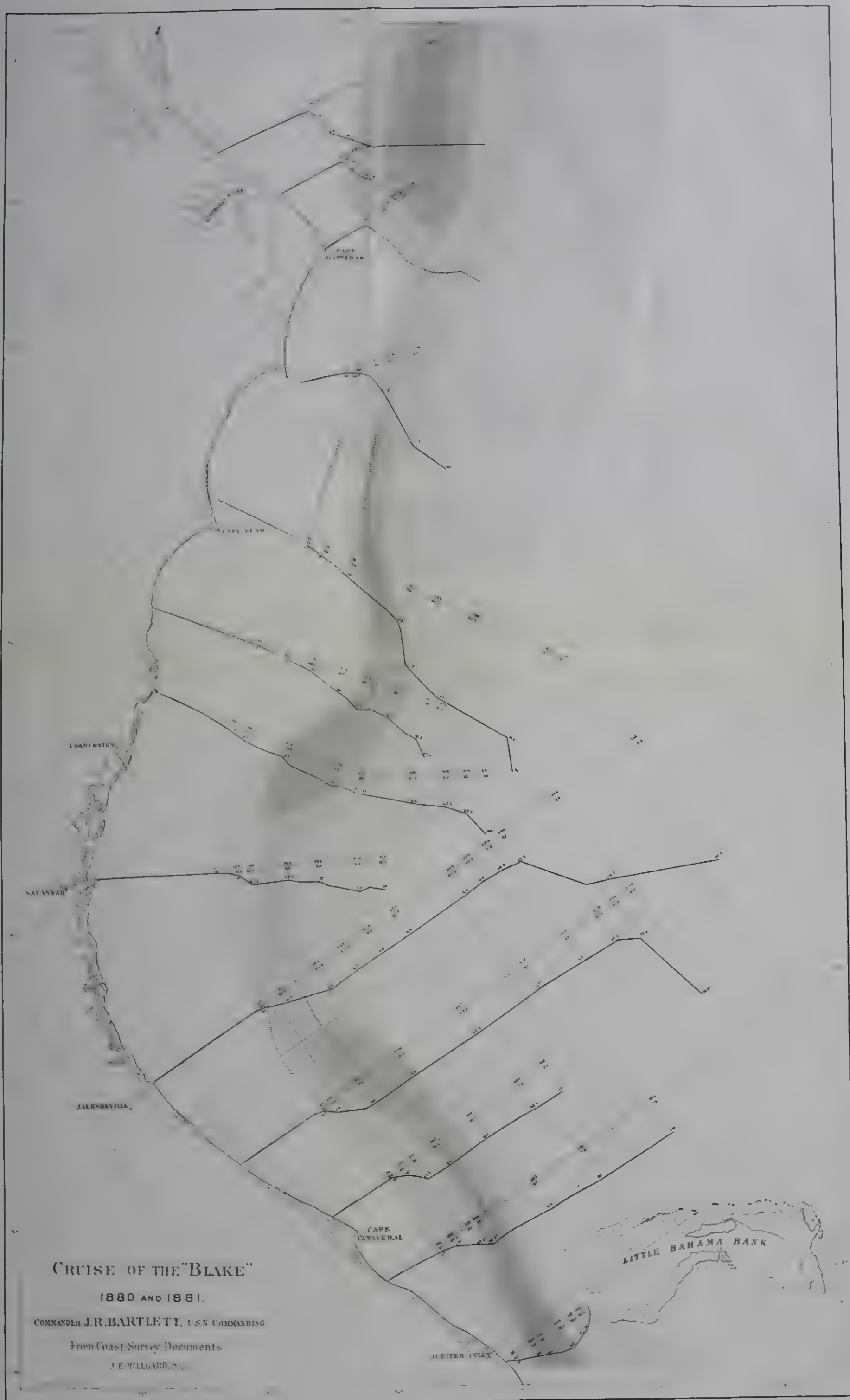
Thus the Gulf Stream now flows north of the Straits of Bemini upon this comparatively shallow submarine Blake plateau,* of an average depth of about 450 fathoms, and finally pours into the deep water of the Atlantic over the edge of the steep slope south of Cape Hatteras. At the same time it precipitates on this slope all the silt it has carried along on its bottom, and which represents for the greater part the wearing action of the Gulf Stream in its course northward. A similar action, but on a smaller scale, also takes place on the steep western and northeastern slopes of the Yucatan Bank. The shallow surface waters of a part of the Stream pour over this bank, and deposit along the above-named slopes all the silt held in suspense, and whatever materials are picked up along its course due to its action upon the shallow banks and reefs of the great Bank itself.

We have, unfortunately, no very definite data regarding the wearing action of water charged with silt to the degree indicated by the immense quantity of it deposited by the Gulf Stream on the northeastern edge of the Blake plateau, just south of Cape Hatteras. The Mississippi, with a depth of say five fathoms, and a velocity not much greater than that of the Gulf Stream, has in a couple of years dug out a depth of at least eighty feet a short distance back of its bar. Now what may be the wearing action of a mighty river like the Gulf Stream, having perhaps an average depth of three hundred and fifty fathoms, and a breadth of some fifty to seventy-five miles, with a velocity of five miles, it is difficult to say. Supposing, however, that this wearing action is no greater than aerial denudation over the area of the Mississippi drainage basin, — that is, at the rate of one foot in six thousand years (it certainly is not too much to assume the same amount for the grinding action of the Gulf Stream), — this would give us a period of about ten millions of years since the termination of the cretaceous period. This estimate is probably far too high, judging by what we know of the wearing action of water in hydraulic sluices ; we probably have a safer estimate in a period of five millions of years as indicating the time which has elapsed since the beginning of the Tertiary. If we assume with Ramsay that this represents about one tenth of the time which has probably elapsed since

* The different shades on the map correspond with the respective velocities of 1, 2, 3, 4, and 5 knots per hour.

life appeared on the earth, this would give us a total of not more than fifty million of years since the first appearance of life upon this globe. To this must be added as the age of the globe whatever time mathematicians think necessary to reduce the globe to a condition fit for animal life from its primitive state.

CAMBRIDGE, May 23, 1883.


CAPE HATTERAS
CAPE FEAR
CHARLESTON
SAVANNAH
JACKSONVILLE
CAPE CANAVERAL
JUPITER INLET
LITTLE BAHAMA BANK
CRUISE OF THE "BLAKE"
1880 AND 1881.
COMMANDER J. R. BARTLETT, U.S.N. COMMANDING
From Coast Survey Documents

No. 3.—*Exploration of the Surface Fauna of the Gulf Stream, under the Auspices of the United States Coast Survey, by* Alexander Agassiz.

IV.

On a few Medusæ from the Bermudas. By J. Walter Fewkes.

LIST OF FREE JELLY-FISHES FOUND IN CASTLE HARBOR, BERMUDA, IN MAY AND JUNE, 1882.*

Aurelia flavidula Per. et Les.
Pelagia cyanella Per. et Les.
Linerges Mercurius Haeck.
Mnemiopsis Leidyi A. Ag.
Pleurobrachia rhododactyla Ag.
Beroë punctata Cham. et Eys.
Chiaja † multicornis M. Edw.
Physalia Arethusa Til.
Velella mutica Bosc. (fragment).
Agalma Okenii Esch.
Stephanomia (Forskalia) Atlantica F.
Rhizophysa filiformis Lam.
Rhizophysa Eysenhardtii Geg.
Diphyes acuminata Leuck.
Diphyes formosa F.
Lizzia octopunctata Forbes.
Dysmorphosa fulgurans A. Ag.
Halitiara formosa F.
Modeeria multitentacula F.

* During my stay in the Bermudas very little pelagic life was seen. The above list probably contains only a small part of those jelly-fishes which frequent its waters.

† The name *Eucharis* was preoccupied in 1825, when first applied to this Ctenophore. The name is as old as 1809 among the Mollusks.

Modeeria (Turritopsis) nutricula F.
Tima formosa A. Ag.
Oceania languida A. Ag.
Eucheilota ventricularis McCr.
Cunina discoides F.
Unknown **Ephyra** with sixteen tentacles.
Tamoya punctata sp. nov.
Eucheilota quadralis sp. nov.
Oceaniopsis Bermudensis gen. et sp. nov.
Ectopleura sp.
Eucope sp.

Unknown Ephyra with sixteen tentacles.

Fig. 16.

An Ephyra, which was at first regarded as the young of *Linerges*, on closer examination was found to have sixteen instead of eight otocysts, and the same number of tentacles. In many other respects, however, it closely resembles the young *Linerges*. The bell is flat, disk-shaped, with a slightly raised and rounded apex. The marginal lappets, which are thirty-two in number, are long and flat, thin and pointed at their free extremities. When they are extended, the central region of the bell, as seen from one side, appears as a slight protuberance above the plane in which they lie. When the marginal lappets of the bell are contracted, they fold under the oral side of the bell so that their tips meet at a point in the centre below the mouth. The incisions which separate the marginal lappets of the bell extend to two depths; one set of incisions corresponding to the position of the tentacles, and the other to that of the sense bodies. The former are the deepest, and the bell margin is cleft by them in such a way that the rim of the bell is divided into sixteen pairs of marginal lappets. The color of the bell is a brownish yellow, in which are darker spots and patches of black pigment. The mouth is simple, like that of the young *Linerges*, and from its lips hangs a single row of small papillæ, which are wanting in the Ephyra of *L. Mercurius*, Haeck. The adult of the Ephyra will certainly be found to be a very unusual Discophore. Three genera which it approximates in the number of marginal sense-bodies are *Cassiopea*, *Collaspis*, and *Atolla*. From both of the last two, however, it differs so widely in the form of the bell and other particulars that it cannot be referred to either of them. *Cassiopea*, which has sixteen otocysts, has no tentacles in the youngest larvæ studied.* The Ephyra of *Linerges* is easily distinguished from that described

* The only genus to which I have been able to refer this Ephyra is *Cassiopea*. *Cassiopea* (*Polyclonia*) *frondosa* is one of the most common Medusæ on the shoals along the Florida Reefs, and probably is also found in the Bermudas, although I

above, in having eight otocysts and the same number of rudimentary tentacles alternating with them on the bell margin. The marginal lappets, instead of being long and pointed, as in the above Ephyra, are rounded, and almost oval in contour. The tentacles are very short, resembling little buds in the interval alternating between the marginal bell lappets.

The youngest Ephyra of *Linerges* which was taken is much younger than any yet figured. The umbrella has a disk-like form, is flat, and has a coloration similar to that of the adult. It was not traced into a larva like that which is elsewhere* doubtfully described as the young of *L. Mercurius.*

Agalma Okenii Esch.

Several specimens of *A. Okenii* † were collected in Castle Harbor. This species has never before been taken on this side of the Atlantic. *A. Okenii* resembles our common *Agalma*, *A. elegans* F., but is easily distinguished from it by the rigid character of the body and the thickness and peculiar form of the covering-scales.

The axis in larger specimens is about three inches long, and has little flexibility. The polyp stem, or that part of the axis which bears the polypites and their covering-scales, is almost straight, and on account of the thickness and close approximation of the covering-scales is never thrown into those curves which impart so much grace to the *Agalma* when in motion. The color of the axis is yellow and orange. The float and axis resemble in most of their external features the same structures in *Agalma*. The swimming-bells are similar to those of *A. papillosum* F. in possessing blind extensions of the bell cavity into the gelatinous horns which arise on either side of the attachment to the axis and embrace the stem.

The covering-scales are very thick, and stand out at right angles to the stem at their points of attachment. In looking at the Physophore from the side, it

was not successful in my search for it. *Cassiopea* has sixteen sense-bodies, and in that respect differs very widely from most Discophora. In one or two other genera, as *Collaspis* and *Atolla*, there are more than eight marginal sense-bodies, but the differences between these genera and the Ephyra mentioned seem too great for a reference of it to them.

If my Ephyra is in reality the young of *Cassiopea*, or some other genus with like sedentary habits, it furnishes us with the interesting fact, which I have long suspected, that in its younger larvæ *Cassiopea* is free-swimming, and has embryonic tentacles in the Ephyra which are lost in the adult.

* Bull. Mus. Comp. Zoöl., Vol. IX. No. 7.

† This species of *Agalma* closely resembles *Crystallodes rigidum* Haeck., with which it is probably identical. It seems also to be the same as a Siphonophore described by Gegenbaur, from the South Atlantic, lat. 2° S., long. 26° W. (Neue Beiträge zur näheren Kenntniss der Siphonophoren). I have followed the latter author in considering it the same as the *Agalma Okenii* described by Eschscholtz, from the North Pacific Ocean.

will be noticed that the flat faces which make up the sides of the animal below the swimming-bells are not formed, as in *A. elegans*, by the upper surfaces of the covering scales, but by planes of the same at right angles to the upper and lower surfaces of the bract. These faces are produced by the great thickness of the scale. Its breadth is simply the thickness of the distal edge of the scale. The upper surface of the lowest covering-scale is flat, and fits closely to the lower surface of that bract which is immediately above it in the series, and so on throughout the whole length of the polyp-stem to the lowest nectocalyx. The thickened border of the bract does not present, when seen from the side, a single continuous plane surface, but is made up of three or four slightly concave furrows, separated by ridges, which extend at right angles to the upper face of the scale, in the direction of the length of the stem. Both the swimming-bells and the covering-scales are infested with *Distomæ.* The appendages to the polyp-stem all arise from one side of the axis and hang downward in such a way that when the axis is extended longitudinally the free extremities of the polypites slightly protrude beyond the covering-scales. The polypites are more highly colored than those of *Agalma.* No tasters were observed. The tentacles resemble in character and origin those of *A. elegans* F. Each tentacular knob has a coiled sacculus, a well-developed involucrum within which it can be drawn, and two lateral terminal filaments, one on each side of a median vesicle. The distal extremities of the lateral filaments are slightly enlarged, and colored with reddish pigment.

NOTE.—It may be found, when older larvæ of *A. papillosum* F. are studied, that it is the same as *A. Okenii* Esch.

Rhizophysa Eysenhardtii (?) GEG.

A single specimen of *R. Eysenhardtii* (?) was taken in Castle Harbor. The species is well marked, and can easily be distinguished from *R. filiformis** by the absence of tentacular knobs on the tentacular filaments. When first taken from the water, the tentacles cling with the greatest pertinacity to whatever foreign body they touch. *R. filiformis* is also said to grasp any adjacent object in the same way; but those which I have studied do not fasten the tentacles with the same persistency as *R. Eysenhardtii.*

* The anatomy of the above species of Bermuda *Rhizophysa* resembles closely that of *R. planestoma* Per. et Les., although in the figures of this species no side branches to the tentacles are represented. It also agrees closely in form with a species of *Rhizophysa* described by Huxley, from the Indian Ocean. In the Bermuda species no sexual clusters were found at the base of the feeding polyps, as mentioned by Huxley in his species.

Several specimens of *R. filiformis* were found at Bermuda; one of these measured over three feet in length. In this specimen the sexual bells were very large, and resemble very closely the sexual bodies of *Physalia.*

The extended axis of the specimen captured was a foot and a half long. The size of the float, as compared with the diameter of the stem, is proportionally very large, as in *Athorybia* and *Physalia.* Its apex has a crimson color, and its apical walls are broken through by a circular opening. The longitudinal axis of the float swims vertical upon the surface of the water.* Cellular appendages hang from the lower portion of the air-sac into the cavity of the float. The axis is slender, very contractile, and has a pale pink color, while that of *R. filiformis* is greenish in color. When the stem is retracted it forms a twisted snarl below the float, but at other times, when the *Rhizophysa* floats extended in the water, the tentacles and their side branches reach widely outward, and the polypites are turned at right angles to the stem. Just below the float the polypites are quite small, numerous, arise close together, and are destitute of tentacles. Their outer walls have a pale pink color, with more of an orange tinge than the axis and tentacles. The inner walls of the larger polypites bear characteristic "villi," like those described by Huxley in *Physalia*, and likewise a prominent dark brown, almost black body, which closely resembles the "liver" of *Velella.* The "villi" on the inner walls of the polypites of *Rhizophysa* are homologous with the well-known "tubes" which have been described in the liver of *Velella.* The polypites arise from all sides of the axis.

Each of the larger polypites bears a single long flexible tentacle, which is destitute of tentacular knobs, but possesses filiform side branches, which are thickly set with large cells on one side, where the tentacular walls are enlarged. While many of the side branches are claret-colored, several are colorless. When the animal is captured, the tentacles must be almost torn from objects to which they fasten themselves, before it can be raised out of the water.

The sexual organs resemble those of *R. filiformis* and *R. gracilis* F., and, like those of the former species, arise from the stem midway between two polypites. The close resemblance of the sexual clusters in *Physalia* and *Rhizophysa* has been pointed out elsewhere.† The side branches of the *Rhizophysa* tentacle are homologous with the reniform thickenings on the tentacles of *Physalia.*‡

* The longitudinal axis of the float of *R. filiformis* lies horizontally on the surface of the water.

† Bull. Mus. Comp. Zoöl., IX. 7.

‡ The close likeness between the sexual organs in *Physalia* and *Rhizophysa* was pointed out in my description of *R. gracilis* in 1882. The comparison of the tentacular knobs in these two genera was made by Huxley (Oceanic Hydrozoa). Chun raises these two genera, *Physalia* and *Rhizophysa*, to the rank of an *order*, to which he gives the name "Pneumatophoridæ" (Pneumatophoræ), and which he regards as of equal rank with the Physophoridæ (Physophoræ) and the "Calycophoridæ" (Calycophoræ). In *Rhizophysa gracilis* F. we have a close approximation to *Physalia* in the structure of the body of the tentacle. The "sac," loose folds on one side of this organ in *Physalia*, are likewise found very well developed in the closely allied *Rhizophysa Eysenhardtii* Geg.

Tamoya punctata sp. nov.

Figs. 4–6.

A small *Tamoya*, different from any species of this genus which has yet been described was found several times at the Bermudas. It is probably the young of a species of the genus *Tamoya*, although it has differences from the known species of the genus which may later, when more is known of the development of *Tamoya*, call for its separation. The absence of enlargements of the bases of the tentacles into "wings" separates it from the adult *Tamoya*. The youngest larva (fig. 4) has the following characters. In many respects it resembles *Procharagma* Haeck., from which it however differs in the possession of a well-marked "velarium" and clusters of cells upon the external surface of the bell.

The bell of this larva has very rigid walls, as that of related Trachynemidæ. The bell walls are colorless, and without radiating chymiferous tubes. The height of the bell is a little more than its diameter. Its external surface bears parallel circles of cells, each composed of several small clusters, and arranged as shown in the figures. Instead of radial chymiferous tubes, we find four radial muscles, which extend along the inner bell walls from a point just below the apex of the bell to the marginal sense-bodies.

The proboscis is at first a bag-like fold hanging downward in the bell cavity, and slightly separated from its upper inner walls. It is a little more opaque than the adjacent bell walls, and has a reddish or brownish color. There are four short, stiff tentacles springing from the bell margin. Each is carried projecting outward, and is ribbed on its outer walls with rings of lasso-cells. The tentacles have a reddish color at their extremities.

The sense-bodies are four in number, and are set in deep incisions in the bell margin, midway between the points of origin of the tentacles. Each sense-body is covered externally by a well-developed "hood" (*h*), which is visible even in the youngest specimens. A radial muscular band passes from the base of each sense-body to the stomach, along the inner bell walls. A similar band also makes its way directly from the point of origin of the style of the sense-body into the "velarium." These last-mentioned muscles end blindly near the inner rim of this structure. Each marginal sense-body has the form of a spheroidal sac mounted on a short peduncle. This sac (otocyst) contains a solid spherical body, which occupies most of the chamber of the otocyst opposite that into which the cavity of the style opens. The otolyth is nearly transparent and colorless. There is a pair of ocelli situated in the lateral walls on the sides of each otocyst.

The "velarium" is thick, muscular, and propulsion is brought about by its strokes on the water combined with movements of the bell walls.

A second, somewhat older larva of *T. punctata* was also found. It differs primarily from that just described in the greater length of the tentacles, and in the modification in the shape of that part of the apex of the bell from which the proboscis hangs. While the proboscis of the youngest *Tamoya* springs

directly from the inner wall of the bell cavity, as the larva grows older a rounded protuberance forms in the upper walls of the bell cavity from which the proboscis hangs. This protuberance, when seen from the side, is hemispherical in shape. It forms, however, by means of mesenteries which join the inner wall of the bell in the four meridians passing through the sense-bodies, four pockets, or blind cavities, enclosed by it and the inner bell walls. These pockets are extensions of the bell cavity into the apical walls of the bell, and are separated from each other on the sides by the mesenteries which join the sides of the proboscis and the inner bell walls. In these recesses transparent globules were observed in several specimens. Two of these are represented in Fig. 5.

Figs. 2, 3.

Two small jelly-fishes which are closely related to the above, or are the larvæ of a Medusa like *Tamoya*, were found on several excursions in Castle Harbor. They are slightly smaller than the youngest larvæ of the above-mentioned Acaleph, and for lack of better knowledge have been provisionally referred to *S. punctata.*

The bell walls are thin, rigid, and without chymiferous radial tubes, while the outer surface is destitute of the characteristic cells which have suggested the name *punctata.* The proboscis is very slightly developed, resembling a simple muscular layer split off from the inner walls of the bell below the apex.

The bell margin bears four tentacles alternating with as many sense-bodies, all of which are situated in one and the same plane. The four tentacles are rigid, and crossed by annulations of cells arranged in bands, as in *T. punctata.* Each otocyst is a simple spherical sac, in which is found an otolith. The style which bears the otolith has well-defined pigment spots in its walls; these are probably ocelli. No well-marked "hood," such as exists in *Tamoya*, is yet developed. Near the point of attachment of the otocyst, which has no peduncle, to the bell margin, there is a thickening of the bell margin, forming a protuberance on either side of which are small clusters of nematocysts.

Ectopleura sp.

Fig. 11.

A small Medusa, evidently larval, is referred to the genus *Ectopleura.* Unlike the young* of *E. ochracea* A. Ag., it has only two well-developed tentacles,

* Bull. Mus. Comp. Zoöl., IX. 8. An unknown Tubularian (Fig. 14), probably larval, which was unlike any of the species of American genera, was taken at Newport during my work there last summer. Description of a single specimen:—

Bell colorless, high, with thin walls and well-marked apex, crossed by four broad radial tubes; outer surface irregularly covered with lasso-cells. The tentacles are two in number, and are placed opposite each other on the bell margin. Proboscis mounted on a hemispherical projection of the apex of the bell into the bell cavity. Stomach diminutive, lips small, smooth, slightly colored.

and these are arranged opposite each other on the bell margin. The eight rows of lasso-cells on the outer surface of the bell are similar to those in *E. ochracea.*

The youngest larva of *E. ochracea* from Newport has four tentacles. A larval *Ectopleura* with two tentacles has not been recorded previous to this observation of the Bermuda species.

Fig. 12.

The *Ectopleura* mentioned above was accompanied by several young Tubularians, all in a like stage of development, which could not be placed in any known genus. The outlines of the bell are similar to those of *Sarsia.* Its outer surface is covered with nematocysts, arranged without regularity.

The Medusa is peculiar in possessing two simple tentacles placed opposite each other on the bell rim, and a pair of small, apparently rudimentary tentacles at the extremities of the two remaining chymiferous tubes. These Medusæ are the larvæ of some unknown Tubularian related to *Sarsia.*

Oceaniopsis gen. nov.

The genus *Oceaniopsis* differs from other members of the *Oceanidæ* in possessing four octocysts, from the neighborhood of each of which, on the bell margin, there arise small tentacular filaments.

Oceaniopsis Bermudensis sp. nov.

Figs. 8, 9, 10.

Two stages in the development of this jelly-fish were found. The younger of these has two large, opposite tentacles, while the older has four.

The characters of the former (Figs. 8, 9) are as follows. The bell is low, without raised apex, with smooth external surface and thin flexible walls. There are four spherical ovaries (*s*) which hang from the chymiferous tubes midway between the proboscis and the bell margin. Two long tentacles (Fig. 8) take origin opposite each other on the bell rim. The rudiments of two others (Fig. 9) are plainly visible on the bell rim, midway between the last, as prominent projections on the bell margin. The bell bears four otocysts. From the neighborhood of each otocyst on the bell margin spring three or more, sometimes two, small filaments. No filaments are found, as in *Eucheilota,* in the neighborhood of the tentacular bulbs.

An older stage (Fig. 10) of the same Medusa has four well-developed tentacles, each of which arises from a tentacular bulb, situated at the terminus of the radial tube near the bell margin. There are no other additions of importance in this larva, which is probably not far removed in shape from that of the adult. Several larvæ of *Oceania languida* A. Ag., occurred with *Oceaniopsis.*

These invariably have eight otocysts instead of four, even before the ovaries were developed, and while there are but two tentacles which are opposite each other.

In connection with *Oceaniopsis* it may be well to mention a new species of *Eucheilota*, a young stage (Fig. 13) of which was taken in surface collecting at Newport last summer. This jelly-fish resembles closely the young of *E. ventricularis* McCr., but, unlike it, has only four otocysts. There are two tentacles, which arise diametrically opposite each other on the bell margin, at the junction of radial and circular chymiferous tubes. Near the base of each tentacular bulb there hang two short filaments, as in *Eucheilota*.

The otocysts are situated on the bell rim, half-way between the peripheral end of the radial tubes. Near each otocyst there hangs a short filament, not unlike those situated near the tentacular bulbs.

The single specimen taken was undoubtedly larval, and no indication of the sexual organs was seen. If the number of otocysts does not increase as the larva grows older, this Medusa is probably the young of a new genus; otherwise, it may be the immature form of some well-known Medusa like *Euchcilota*. Provisionally, therefore, I have referred it to *Eucheilota*, and designate it as the young of *E. quadralis* sp. nov.

Cladonema sp.

The genus *Cladonema* has up to the present time never been taken from American waters. A species of this genus, found by Dr. C. O. Whitman near Key West City, in 1883, is in certain particulars different from the *C. radiatum* Du Jardin, and may be found, on a more extended study, to be a new species.

Cladonema was found with *Cassiopea* on the shoals near Fleming's Key.* At the time of capture it was apparently at or very near the sea bottom, and was brought up in a dip-net with sand from the shoal.

The bell is almost spherical, and is destitute of an apical projection. The outer surface is smooth, and the bell walls thin. No indication could be seen, either in sketches of the animal when alive or in the preserved specimen, of a cavity at the base of the proboscis called a "brood sac" in the related genus *Dendronema*.

There are nine chymiferous tubes in the bell walls. Of these tubes, six only originate from the base of the proboscis. Three chymiferous tubes pass directly without sudivision from the proboscis to the bell margin, and three bifurcate a short distance from their origin. The three bifurcating tubes alternate with those which do not divide.

There are nine large tentacles hanging from the bell margin, each at an extremity of a chymiferous vessel. At the base of each there is an "eye-spot" of black color. Two kinds of lateral branches arise from the tentacles. The first

* A mangrove key, a short distance north of Key West, Florida.

kind hang in a small cluster from the under side of the tentacle, not far from the origin of the same from the bell margin. They are said to bear suckers at their distal ends. In the single specimen this structure could not be made out. The second kind of appendages to the tentacles are more slender than the former, and bear along their sides small lasso-cells. These branches are longer and appear more flexible than the former. The manubrium extends from its origin from the inner bell walls to the vicinity of the bell opening. The number of oral tentacles is probably five. Six small lateral projections on the outer walls of the manubrium, about midway its length, indicate the future ovaries or sexual organs.

CAMBRIDGE, August, 1883.

EXPLANATION OF THE PLATE.

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a. Axis.
a a. Float.
b. Contents of polypite (Alga ?).
c. "Peroniæ."
d. Extension of bell cavity into the "velarium."
e. Projection of the bell margin near an otocyst.
f. Mouth (opening into a gastric cavity).
g. Projection into the bell cavity from which the stomach hangs.
h. Hood.
i. Cluster of nematocysts.
k. Annulations formed by rows of nematocysts on the tentacles.
l. Lips.
l p. Labial papillæ.
m. Mouth.
m l. Marginal lappets.
m s. Muscular bands.
o c. Otocyst.
p. Polypite.
p h. "Phacellen." Sexual filaments.
s. Sexual organs.
t. Tentacles.
t t. Tentacular appendages.
v. Velum.

Fig. 1. *Rhizophysa Eysenhardtii* Geg.
" 1ª. Portion of a tentacle of *R. Eysenhardtii.*
" 2. Young of an unknown Medusa.
" 3. The same from below.
" 4. Larva of *Tamoya punctata,* sp. nov.
" 5. Older larva of the same.
" 6. View of *T. punctata* from below
" 7. Larva of an unknown Tubularian.
" 7ª. The same from below.
" 8. *Oceaniopsis Bermudensis* gen. et sp. nov.
" 9. View of half of the same from below.
" 10. The same, from larva somewhat older.

Fig. 11. Larva of *Ectopleura* sp.
" 12. Larva of an unknown Tubularian.
" 13. *Eucheilota quadralis* sp. nov.
" 14. Larva of an unknown Tubularian.
" 15. "Phacellen" of very young *Linerges*.
" 16. Quadrant of the Ephyra of an unknown Discophore.

The Heliotype Printing Co. 211 Tremont St. Boston.

No. 4. — *Reports on the Results of Dredging, under the Supervision of* ALEXANDER AGASSIZ, *on the East Coast of the United States, during the Summer of* 1880, *by the U. S. Coast Survey Steamer "Blake,"* COMMANDER J. R. BARTLETT, U. S. N., Commanding.

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XXIII.

Report on the Isopoda. By OSCAR HARGER.

THE collection of Isopoda from the Blake Expedition, although small in number, is remarkable for the large proportion of interesting forms secured, since nearly all the specimens prove to belong to species that are either new, or not hitherto known from our coast, or to species known only from single specimens and hence only imperfectly described.

CIROLANIDÆ.

Cirolana spinipes BATE & WESTWOOD.

Plate I. Figs. 2-2d. Plate II. Figs. 1-1c.

Cirolana spinipes BATE & WESTWOOD, Brit. Sess. Crust., II., p. 299. 1868.

Specimens of this species, not hitherto recorded from our coast, were obtained from two localities; viz. Station 316, Lat. 32° 7′ N., Long. 78° 37′ 30″ W., 229 fathoms, one female; and Station 321, Lat. 32° 43′ 25″ N., Long. 77° 20′ 30″ W., 233 fathoms, three females and one male.

These specimens appear to agree perfectly in all specific characters with others in the collection of the Yale College Museum identified and sent to the Museum by the Rev. A. M. Norman, from the Shetland Islands. They do, however, differ in some respects from the description of that species in Bate and Westwood's work, and to facilitate comparison with that species and with others on our coast a full description is appended, with figures.

The body is a little more than three times as long as broad, with the dorsal surface strongly rounded, polished and smooth except for minute punctations, mostly near the posterior margin of each segment, and a median dorsal row of shallow oval depressions, most distinct on the third, fourth, and fifth thoracic segments.

The head is quadrate, widest across the posterior part of the eyes, which are oval, and more distinct than in the other species on our coast. A horizontal impressed line passes along the side of the head above and in front of the eye, and another just above the anterior margin over the bases of the antennæ. The antennulæ (Pl. I. Fig. 2 a) are short, not equalling the peduncle of the antennæ. Their basal segments are in contact above and in front; the second segment is short, the third as long as the first two, and is followed by a flagellum not as long as the peduncle and composed of about fourteen short and closely united segments. The antennæ (Pl. I. Fig. 2 b), when reflexed, reach the posterior margin of the third thoracic segment; the first two peduncular segments are short; the third and fourth each twice as long as the second, and of somewhat greater diameter; the fifth is the longest peduncular segment, and, at base, only about half the diameter of the fourth. The slender, tapering flagellum is about twice as long as the peduncle, and composed of twenty-five or more segments. The fourth and fifth peduncular segments bear, near their distal ends, a few slender and rather short bristles, much less conspicuous than in *C. concharum* or *C. polita* (Pl. I. Fig. 1 b), but longer than in the next species, *C. impressa* (Pl. I. Fig. 3 b).

The first thoracic segment is slightly longer than the second; posteriorly the segments increase slightly in length to the fifth or sixth, but the seventh is the shortest. The first segment is marked by an impressed curved line just above the lateral margin. The epimera of the second and third segments are small, subquadrate, rounded behind. The fourth epimeron is larger than the preceding ones, with the lower posterior angle rounded. The fifth and sixth epimera are of about equal size and larger than the others, while the seventh is the smallest of all. In the last three the posterior margin is oblique, and the lower angle is pointed. All the epimera are quadrate in general outline, and from near the middle of the line of union with the segment a sharp depressed line extends upward upon each of the last four segments.

In the first pair of legs (Pl. II. Fig. 1 a) the basis is flattened on the upper or inner side, and slightly curved in adaptation to the convex under surface of the head. The anterior margin of this segment is also fringed with bristly hairs. The succeeding segments are well armed with bristles, and the merus, carpus, and dactylus are armed along their palmar margins also with acute spines; the carpus in this leg is triangular and articulated with little motion to the propodus. The legs of the second and third pairs resemble the first, but have a free articulation between the propodus and carpus, which is oval and armed with several acute spines. These three pairs of legs are directed forward. The fourth and subsequent pairs are directed backward. The legs of the fourth pair (Pl. II. Fig. 1 b) are of moderate length and well armed with bristles or spines throughout, especially on the merus and carpus, where the spines form a striking feature. The palmar margin of both these segments is armed with a row of slender elongated spines and bristles, with many shorter spines also along the margin, while upon the outer or exposed surface of both segments is a pretty regular longitudinal row of short spines, nearly along the middle of

the segment, and others in less regular order between this row of spines and the palmar border. In the English specimens these spines are even somewhat more numerous than in ours. The fifth leg is similar to the fourth, but somewhat longer and more slender, and the spines on the merus and carpus are nearly as pronounced and definitely arranged as in the fourth, while a similar arrangement is found in a less degree upon the remaining two pairs of legs. In the last two pairs of legs the bases are flattened, expanded, and well ciliated, forming strong swimming organs. One of the last pair is figured on Plate II. Fig. 1 c.

All of the pleonal segments are plainly evident above, the first not being at all concealed by the last thoracic segment, as in the other species on our coast. The first four segments are subequal in length on the median dorsal line; laterally they are carinated, the carina ending behind in an angulation (see Pl. I. Fig. 2 c) which is most pronounced on the third segment and is rounded off on the fourth. The thickened, chitinous walls of these segments are more or less continued below the lateral keel upon the inferior surface of the pleon, and in the first two segments the inner and posterior angles of this portion are acutely produced, in the second segment, into short, divergent spiniform processes. In the third, the under part of the segment runs out to its lateral angle, and in the fourth segment this portion is small and not angulated. All these segments are smooth and not ciliated laterally. The fifth segment is small, and does not reach the lateral margin of the pleon. The last segment (Pl. II. Fig. 1) is semioval, acutish at the tip, near which it is ciliated and bears a few short spines. The basal segment of the uropod is produced at the inner angle to about half the length of the outer ramus. This ramus is lanceolate in outline, shorter than the inner, and of only about half its width; both are ciliated and armed with short spinules. The inner is destitute of the emargination seen on the outer border near the tip in the other species. The second pair of pleopods in the male (Pl. I. Fig. 2 d) is armed, on its inner ramus, with a stylet of peculiar form. The stylet is slightly longer than the ramus and very acute at the tip, just below which it is suddenly much expanded and sends off a prong on the outer side, toward the lamella, as shown in the figure. A similar structure is seen in the male from the Shetland Islands, but I have seen nothing like it in the other American species.

Length of female, 23 mm.; breadth, 7.5 mm. The single male specimen obtained is smaller: length, 16 mm.; breadth, 5.5 mm.

Cirolana impressa sp. nov.

Plate I. Figs. 3-3 d. Plate II. Figs. 3-3 c.

This species closely resembles *C. polita* (Stimp.), as may be seen from the figures of the two species (Pl. I. Fig. 1, *C. polita*, Fig. 3, *C. impressa*). They are most readily distinguished by the impressed lines on the surface of the epimera in the present species, but a closer inspection brings to light other characters, as will appear in the following description.

The body is more than three times as long as broad, with the sides nearly straight and parallel, smooth and polished, with fewer punctations than in *C. polita*, but with the usual median dorsal row.

Head rounded hexagonal, broadest across the eyes, with an impressed line just above them extending around the front of the head. Eyes small, subtriangular, notched on their front outline by a thickened marginal ridge, which dies out in the ocular region. Antennulæ (Pl. I. Fig. 3 a) about as long as the peduncle of the antennæ; two basal segments swollen and together longer than the third; flagellum as long as the peduncle, composed of about a dozen segments, shorter and more closely articulated than in *C. polita*. (Pl. I. Fig. 3 b). Antennæ surpassing the margin of the first segment, shorter than in the preceding species; flagellum one half longer than the peduncle and composed of about twenty-two segments.

First thoracic segment closely adapted to the hinder margin of the head, about twice as long on the median line as the second. Behind the second, the segments gradually increase in length to the seventh, while in *C. polita* the fifth is the longest segment and the seventh is shorter than the sixth. The first segment is marked in the epimeral region by a nearly marginal impressed line. In the following segments the epimera are distinct and increase in size to the last. The second and third epimera are subquadrate, with rounded posterior angles, much as in *C. polita*, but each is marked by a curved impressed line below and somewhat behind the middle. The third and fourth epimera are also quadrate in outline, the posterior margins becoming oblique and meeting the inferior margin in each at an angle, while in *C. polita* both these epimera are rounded behind. In the present species, moreover, both these epimera are marked with an oblique impressed line running from near the middle of the upper margin toward the lower posterior angle. The last two epimera are subtriangular in outline, as in *C. polita*, and the sixth is marked with an impressed line, much as in the fourth and fifth. A similar line is faint, or represented by a row of punctations, on the last epimeron. The impressed lines on the epimera of this species serve also to distinguish it from *C. concharum* (Stimp.), to which it has considerable resemblance.

In the first pair of legs (Pl. II. Fig. 3 a) the merus is large and produced at its outer angle beyond the middle of the propodus, its palmar margin is armed with acute spinules much as in *C. polita*, but not quite as strong as in that species (Pl. II. Fig. 2 a), while it differs from *C. concharum* (Pl. II. Fig. 4 a) in lacking the row of blunt spinules near the palmar margin of this segment. The legs of the fourth pair (Pl. II. Fig. 3 b) are armed with spines, with comparatively few bristles among them, and the spines upon the surface of the merus and carpus are arranged transversely, instead of as in the last species. In the seventh pair of legs (Pl. II. Fig. 3 c) the basis is slender and nearly naked, as in *C. concharum* (Pl. II. Fig. 4 c), and the three following segments are flattened and furnished with close-set bristles distally.

The pleon (Pl. I. Fig. 3 c) is more overlapped and concealed by the last thoracic segment than in either *C. concharum* (Pl. I. Fig. 4) or *C. polita* (Pl. I.

Fig. 1 c). The first segment is quite concealed above, and the second more or less concealed also in the ordinary position of the segments. In the ventral portions of the first three pleonal segments the posterior angles are rounded instead of being acute, as in both the *C. polita* and *C. concharum;* laterally the second, third, and fourth segments are ciliated, as in both those species. The telson (Pl. II. Fig. 3) is much like that of *C. polita* (Pl. II. Fig. 2). The uropods have the basal segment produced internally; the outer ramus is about half as wide as the inner, which has a distinct notch near the distal end of the outer border and is obliquely truncate, or, in the larger specimens, emarginate at the end; both rami, like the end of the telson, are strongly ciliated, but sparingly spinulose. The telson is distinguished from that of *C. concharum* (Pl. II. Fig. 4) by the emargination at the tip in that species. The stylet on the second pair of pleopods in the male (Pl. I. Fig. 3) is simple, ensiform, and tapers to a blunt point; it surpasses the lamella to which it is attached.

The four large females of this species obtained by the Blake Expedition measure in length 21–23 mm. and in breadth 6–6.5 mm. Specimens obtained by the U. S. Fish Commission are many of them smaller, but vary from 15 to 27 mm. in length.

The specimens were obtained at Station 336, Lat. 38° 21′ 50″ N., Long. 73° 32′ W., from a depth of 197 fathoms. Others have also been obtained by the U. S. Fish Commission at the following stations:—

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
871	115	40° 2′ 24″	70° 23′ 40″	4
949	100	40° 3′	70° 31′	11
1094	301	39° 57′	69° 47′	1
1095	321	39° 55′ 28″	69° 47′	2

ÆGIDÆ.

Æga psora (Linné) Kröyer.

One specimen from 306 fathoms at Station 303 in Lat. 41° 34′ 30″ N., Long. 65° 54′ 30″ W.

? Æga Webbii (Guérin) Schiödte & Meinert.

Pterelas Webbii Guérin, Mag. Zoöl., Classe VII., Pl. XX. 1836.
Æga Webbii Schiödte & Meinert, Naturhist. Tidssk., R. III., B. XII., p. 347. Pl. X. (Cym. IV.) Figs. 1–4. 1879.

A single immature specimen of this, or a closely allied species, was taken at Station 307, Lat. 31° 57′ N., Long. 78° 18′ 35″ W., from a depth of 333 fathoms. It measures 10.5 mm. in length, 5.5 mm. in breadth, and has not yet developed the seventh pair of legs, but the propodi of the second and third pair of legs are armed with the characteristic cultriform spine, and I have referred it to this species, though not with certainty.

Ægа incisa Schiödte & Meinert.

Plate III. Fig. 1.

Æga incisa Schiödte & Meinert, Naturhist. Tidssk., R. III., B. XII., p. 373, Pl. X. (Cym. IV.) Figs. 13–15. 1879.

A single specimen, apparently of this species, was taken at Station 307, from a depth of 333 fathoms, in Lat. 31° 57′ N., Long. 78° 18′ 35″ W.

It agrees so closely with Schiödte and Meinert's description that I have little doubt of its identity with that Mediterranean species, although the body is proportionally narrower and the segments of the pleon more regularly curved above than represented in the figure of *Æ. incisa* given by those authors.

In our specimen the body is nearly three times as long as broad, sparingly punctate, well rounded above.

The head is rounded behind, presenting no ocular lobes; in front it is produced into a distinct, pointed process projecting downward between the bases of the antennulæ, separating them and nearly touching the frontal lamina, which is small and rhomboidal. The first two segments of the antennulæ are short and small, and rounded in front, not enlarged as in *Æ. psora* Kröyer; the third segment is longer than the first two, and is followed by a slender flagellum, longer than the peduncle, composed of about fifteen segments, of which the first is the longest, being as long as the next two, instead of "quam secundo paulo longiore," as in the typical specimen of the species. The antennæ, when reflexed, surpass the second thoracic segment; the flagellum is longer than the peduncle, and composed of less than twenty segments.

The eyes are large, and meet broadly on the median line; ocelli in about ten horizontal rows, half of which meet on the median line in front.

The first thoracic segment is longer than the second, thence they increase slowly in length to the fifth or sixth, and the seventh is short. The epimeral region of the first segment is marked by an obliquely descending depressed line. The epimera are all angulated behind, though only the last two are sensibly produced, and all are marked by one or two oblique curved lines, running downward and backward, the posterior one ending in the lower angle. The last epimeron does not attain the lateral angle of the first segment of the pleon. The legs are weak, and armed with but few small and short spinules throughout.

All the segments of the pleon are evident, but the first is very short above; the first four are distinctly angulated laterally. The telson is subtriangular, distinctly notched behind, as well as minutely crenulated and spinulose. The basal segment of the uropods is produced internally about half the length of the inner ramus, which is obliquely elongate triangular, larger and broader than the narrowly ovate outer one; both are ciliated and minutely denticulate.

Length, 13.5 mm.; breadth, 5 mm.

I have seen no other specimens.

Rocinela oculata sp. nov.

Plate III. Figs. 2-2a. Plate IV. Fig. 1.

Body oval, length a little more than twice the breadth, surface sparsely punctate.

Head subreniform, produced in front into a truncated process over the bases of the antennulæ, yoke-shaped behind, the ocular lobes projecting, upper surface nearly covered with the large eyes in which the ocelli are large and quincuncially arranged in ten rows along the long axis of each eye. Five of these rows meet along the median line.

The antennulæ are slender and scarcely attain the tip of the antennal peduncle; the basal segment is short and concealed from above; the second is longer than the first; the third is slender, but not as long as the first two together; flagellum about as long as the peduncle, slender and composed of five segments, of which the first is much the longest and the last is the shortest, and does not quite attain the posterior border of the eye when the antennula is reflexed. The antennæ surpass the first thoracic segment; the first two segments are very short; the flagellum is about twelve-jointed.

First thoracic segment closely adapted to the head in front; fourth segment longest on the median line above; sixth short; seventh nearly concealed and quite small, although bearing a well-developed pair of legs below.

The epimera of the second and third segments are oblique, but not acute nor produced backward in a lateral view; in the four following segments they are produced and very acute; the seventh epimeron is much smaller than the sixth, and, owing to the shortness of the seventh segment, ends behind about on a line with it, both epimera surpassing the first segment of the pleon.

Legs of the first pair (Pl. IV. Fig. 1) slender, armed with a long slender dactylus, much curved near its base; propodus expanded with a large palmar lobe armed with a marginal row of eight curved spines; carpus short, with a single curved palmar spine. Legs of the second and third pair much like the first, but with only six spines on the propodus. Legs of the fourth and posterior pairs slender, armed with spines principally at the distal ends of the ischium, merus, and carpus.

First segment of pleon very short and nearly concealed by the thoracic segments, narrower than the next three segments, which are about equal, acutely produced at the sides so as to resemble in shape the seventh epimeron; fifth segment narrower than fourth, but somewhat longer on the median line; telson semi-oval, regularly rounded behind and ciliated. Uropods equalling the telson; inner angle of basal segment produced, about one third the length of the inner ramus, which is ligulate, rounded behind, slightly shorter than the outer, and less than half as broad; outer ramus obovate, spinulose along the outer border; both rami ciliated except near the base.

Length, 13.5 mm.; breadth, 6 mm.

A single specimen of this species, the only one as yet known, was taken at Station 305, Lat. 32° 18′ 20″ N., Long. 78° 43′ W., from a depth of 252 fathoms.

Rocinela Americana Schiödte & Meinert.

Plate III. Figs. 3, 3a, 4. Plate IV. Figs. 2, 2a.

Rocinela Americana Schiödte & Meinert, Naturhist. Tidssk., R. III., B. XII., p. 394, Pl. X. (Cym. IV.) Figs. 16–18. 1879.

Two specimens of this species were obtained at Station 320, Lat. 32° 33′ 15″ N., Long. 77° 30′ 10″ W., from a depth of 257 fathoms, and a considerable number of other specimens obtained at various localities by the U. S. Fish Commission enable me to add somewhat to Schiödte and Meinert's description of the species, which was drawn from a single female specimen. A comparison of their type, from Trenton,* Maine, now preserved in the Museum of Comparative Zoölogy at Cambridge, and kindly loaned for the purpose by Professor Agassiz, shows no differences that can be regarded as specific.

The body is oval, with the length more than twice the breadth, and nearly all of our specimens are proportionally broader than the type, although none of them are quite as large.

Head subtriangular, rounded behind, acutish or slightly produced in front, more distinctly produced and somewhat angulated in front in the males (Pl. III. Fig. 4). Eyes rather large, separated by about one quarter the diameter of the head, rounded behind, more or less angulated at the point of nearest approach, where, in the males, a distinct angle of a hexagon is seen at the meeting of two rows of nine and six ocelli along the inner margin of the eye, one ocellus at the angle being common to both rows.

The antennulæ, when reflexed, only slightly surpass the head, and the flagellum is composed of five or six segments, of which the first is not much elongated and the last nearly attains the end of the antennal peduncle. The antennæ nearly attain the hinder margin of the second thoracic segment; the first and second segments are very short and concealed by the projecting front; the flagellum is as long as the peduncle, and composed of about fourteen segments.

The first thoracic segment is slightly excavated for the ocular lobes of the head; epimera of second and third segments subquadrate, oblique but not acute behind, marked with an impressed line near the lower margin; remaining four epimera acute and moderately produced; last epimeron usually surpassing the first segment of the pleon, although in some of the larger females, as in the type specimen, it fails to do so.

Prehensile legs (Pl. IV. Fig. 2) armed with three acute spines on the palmar margin of the propodus, and three obtuse spines on the same margin of the

* Trenton is incorrectly printed "Ireston" in Schiödte and Meinert's paper.

merus; carpus short. Ambulatory legs (Pl. IV. Fig. 2 a), well armed with spines.

First segment of pleon small, nearly concealed by the last thoracic segment, and usually surpassed by the last pair of epimera, narrower than the three following segments, which are slightly broader than the last thoracic segment without the epimera. Last segment broader than long, rounded and ciliated behind, faintly furrowed on the median line posteriorly. Uropods about equal to the telson; basal segment more or less produced at the internal angle, outer ramus shorter than the inner, both rounded behind and ciliated, denticulated externally, with short spinules in the notches between the teeth.

The female specimens vary in length from 14 mm. to 25 mm. and in breadth from 6 mm. to 10 mm., being mostly slightly broader in proportion than the type specimen, which is 26.5 mm. long, 10 mm. broad. The large male in the Blake Collection is 28 mm. long, 12 mm. broad; the small female, 17.5 mm. by 7 mm. A male collected by the U. S. Fish Commission at Station 871 is 22 mm. long, 9.5 mm. broad.

The typical specimen of this species is destitute of color markings, which may however have faded out from exposure to the light. Nearly all the other specimens are rather distinctly marked, chiefly along the sides of the body, with dark brown, arranged as follows. The lateral margins of the first thoracic segment, and the epimera sometimes of the third, and usually of the fourth, fifth, and sixth segments, but not of the seventh, are dark or nearly black, and the color extends distinctly to the adjacent regions of the fourth segment, and may extend across the back along the hinder margin of this segment; the next two segments may be similarly, but less strongly marked. On the pleon the color appears as a curved or crescentic band, along the lateral margins of the second, third, and fourth segments, and across the back part of the fifth and fore part of the sixth segments. On the sixth segment the color when present is divided by the median line into two more or less distinct spots, or maculæ. The posterior part of the telson is lighter-colored than the body.

This species has also been obtained by the U. S. Fish Commission at the following stations: —

Station.	Fathoms.	N. Lat.	W. Long.	Specimens.
871	115	40° 2′ 54″	70° 23′ 40″	5
874	85	40° 0′	70° 57′	Cast skin.
875	126	39° 57′	70° 57′ 30″	1
897	157	37° 25′	74° 18′	2
1108	101	40° 2′	70° 37′ 30″	1
Oct. 4, 1882	Trawl-line			1

Rocinela sp.

A single specimen, probably of an undescribed species of this genus, was obtained at Station 344, Lat. 40° 1′ N., Long. 70° 58′ W., from 129 fathoms.

This specimen, although 27 mm. in length, is not yet adult, as shown by the rudimentary condition of the seventh pair of legs, and differs from the preceding especially in having the eyes more finely granulated. The material is too incomplete to attempt a full description.

Syscenus infelix Harger.

Plate III. Figs. 5, 5 a. Plate IV. Figs. 3-3 h.

Syscenus infelix Harger, Rep. U. S. Fish Com., Pt. IV. for 1878, p. 387. 1880.

Three specimens of this species were obtained at two localities; viz. a single female at Station 303, Lat. 41° 34′ 30″ N., Long. 65° 54′ 30″ W., from 306 fathoms, and two males at Station 309, Lat. 40° 11′ 40″ N., Long. 68° 22′ W., from 304 fathoms. Besides these specimens a considerable number have also been obtained by the U. S. Fish Commission, from various localities along the coast as far south as Delaware Bay, and from a depth as great as 372 fathoms, so that the species, originally described from a single specimen, has now become comparatively common in the collection, and I am enabled to make some corrections in the description already given, as well as to add further details and present figures of the species.

Many of the specimens since obtained are larger than the type, and such examples often have the body quite distinctly corrugated and rather coarsely pitted, especially upon the head and the anterior part of the thorax or pereion. In some of the larger males the ocular regions on each side of the head are swollen and distinctly pitted and corrugated. On the lateral margin of the head is a notch, into which may be received a short process on the anterior angle of the first segment, thus producing a very firm articulation when the head is drawn closely against the first segment. The flagellum of the antennula is usually composed of seven segments instead of six, but the number may be different on opposite sides of the same specimen. A bottom view of the head, enlarged eight diameters, is given on Plate IV. Fig. 3, showing the antennary organs, the right antenna being removed to show the antennula of that side.

The maxillipeds (Pl. IV. Fig. 3 c) are robust, thickened along the inner or median side where they meet; the first segment of the palpus is large, nearly square, and armed at its inner distal angle with a single hook; its distal margin is shorter than the proximal, and is angulated at the articulation with the second short transverse segment. This segment is armed distally with three hooks, of which the anterior appears to be articulated and should perhaps be regarded as a third segment of the palpus. The outer or second maxillæ are thin, delicate, and obscurely lobed at the tip, where they are armed with a single small hook. The inner or first maxillæ (Pl. IV. Figs. 3 b, 3 b′) are armed with spines, of which the inner are shorter and straight, the outer are larger and

curved or hooked at the tip. The mandibles (Pl. IV. Fig. 3 a) are robust at base, but slender and acute at the tip.

In the prehensile, or first three pairs of legs, the merus, carpus, and propodus are each armed with a short, curved, blunt spine on the palmar margin, as shown in the figure of a leg of the first pair on Plate IV. Fig. 3 d. The remaining four pairs of legs, not all natatory, are well fitted for prehension by their slender curved claws, and differ considerably in their proportions in specimens of different sizes, as shown by the accompanying table of measurements. All the legs are strongly flexed at the articulation of the basis with the ischium. In the sixth and seventh pairs, the ischium, merus, carpus, and propodus are elongated and in the small specimens slender, so that, with the addition of the dactylus, the last five segments of the leg of the sixth pair may attain to five sixths or even seven eighths the length of the body. The bases do not participate in this elongation and are therefore omitted in the measurements, since to include them would only diminish the contrast between the large and small specimens, shown especially in the last six columns of the table. In large specimens, like the one figured, the sixth and seventh pairs of legs are much more robust than in smaller ones.

The pleopods (Pl. IV. Fig. 3 g) are not naked, as originally described, but all the anterior ones, as usual in the *Ægidæ*, are distinctly ciliated. The cilia are however short and not very evident, and were overlooked in the single specimen described. In the small specimens they are proportionally longer than in larger ones. The second pair of pleopods in the male (Pl. IV. Fig. 3 g) bears a slender stylet tapering to the tip, and about as long as the ramus to which it is attached. In the small specimen, whose measurements are given in the last column of the table, the stylet is blunt, and considerably shorter than the ramus. The uropods (Pl. IV. Fig. 3 h) are robust; the basal segment is oblique, but not much produced internally; the rami are well ciliated.

Professor Verrill states that in life this species is bright colored, varying from bright orange to salmon-colored above and light yellow underneath. This color soon fades in alcohol.

Considerable variations in size, and corresponding variations in the proportions, especially of the sixth and seventh pairs of legs, are shown in the following table of measurements, in which the first three columns contain measurements of the Blake Expedition specimens, the next four columns contain measurements of specimens obtained at a single locality (Station 945) off Martha's Vineyard, by the U. S. Fish Commission in the summer of 1881, while in the last column are measurements of a smaller specimen obtained by the Fish Commission at another locality (Station 1028) in the same region. The measurements in the fourth column are from the specimen figured on Plate III. Figs. 5 and 5 a; those of the next five columns are from specimens gradually decreasing in size to the last. The length of the ambulatory legs, especially those of the sixth and seventh pairs, is seen to increase proportionally as the length of the body diminishes, except in the case of the seventh pair of legs of the last specimen. This is doubtless to be explained as a mark of

immaturity in addition to the one already noted in the second pair of pleopods. The measurements are in millimeters, and the proportion of each to the length of the body is indicated by the accompanying decimal.

MEASUREMENTS.*

Syscenus infelix H.	B. ♀ 303	B. ♂ 309	B. ♂ 309	F. C. ♂ 945	F. C. ♂ 945	F. C. ♂ 945	F. C. ♀ 945	F. C. ♀ 945	F. C. ♂ 1028
Length of body	1.00 24.5	1.00 31.0	1.00 30.0	1.00 44.0	1.00 32.0	1.00 27.0	1.00 25.0	1.00 18.0	1.00 15.0
Transverse diameter of head	.16 3.8	.16 5.0	.15 4.5	.14 6.0	.16 5.0	.15 4.0	.16 4.0	.18 3.2	.19 2.8
" " 1st segment	.33 8.0	.29 9.0	.31 9.2	.28 12.5	.28 9.0	.30 8.0	.32 8.0	.33 6.0	.33 5.0
" " 3d segment	.36 8.8	.35 11.0	.35 10.5	.34 15.0	.33 10.5	.33 9.0	.36 9.0	.41 7.4	.35 5.2
" " 7th segment . . .	.27 6.5	.26 8.0	.27 8.0	.26 11.5	.25 8.0	.23 6.2	.26 6.6	.25 4.5	.27 4.0
" " pleon at base . . .	.20 5.0	.18 5.5	.18 5.5	.19 8.0	.17 5.5	.17 4.5	.20 5.0	.20 3.6	.20 3.0
" " last segment of pleon	.23 5.6	.23 7.2	.26 7.8	.25 11.2	.24 7.5	.21 5.6	.23 5.8	.22 4.0	.21 3.2
Longitudinal diameter of last segment of pleon	.23 5.6	.26 8.0	.29 8.6	.27 12.0	.26 8.2	.21 5.6	.23 5.8	.25 4.5	.27 4.0
Length, beyond basis, of leg of 3d pair . . .	.18 4.5	.16 5.0	.17 5.0	.14 6.0	.18 5.2	.15 4.0	.17 4.2	.17 3.0	.20 3.0
" " " " 4th pair . .	.30 7.0	.26 8.0	.27 8.0	.25 11.0	.25 8.0	.26 7.0	.28 7.0	.28 5.0	.33 5.0
" " " " 5th pair . .	.37 9.0	.35 11.0	.33 10.0	.30 13.0	.31 10.0	.33 9.0	.34 8.5	.42 7.5	.40 6.0
" " " " 6th pair . .	.66 16.0	.58 18.0	.53 16.0	.45 20.0	.50 16.0	.63 17.0	.68 17.0	.83 15.0	.87 13.0
" " " " 7th pair . .	.53 13.0	.50 15.5	.47 14.0	.41 18.0	.42 13.5	.54 14.6	.60 15.0	.67 12.0	.61 9.2

* In the table of measurements B. is used to denote the Blake Expedition, F. C. the U. S. Fish Commission, and the accompanying numbers refer to the stations at which the specimens were obtained. The measurements are in millimeters, and over each is placed in small figures the corresponding decimal part of the length of the body.

NEW HAVEN, September 6, 1883.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. *Cirolana polita* Harger ex Stimpson. Lateral view of female, enlarged three diameters.
" 1 a. Antennula of another specimen, enlarged twelve diameters.
" 1 b. Antenna of same, enlarged twelve diameters.
" 1 c. Lateral view of pleon of *C. polita* as in fig. 4, enlarged five diameters.
" 2. *Cirolana spinipes* Bate & Westwood. Lateral view of female, enlarged three diameters.
" 2 a. Antennula of another specimen, enlarged ten diameters.
" 2 b. Antenna of same, enlarged ten diameters.
" 2 c. Pleon of *C. spinipes* as in fig. 4, enlarged five diameters.
" 2 d. Pleopod of the second pair of *C. spinipes*, male, enlarged eight diameters.
" 3. *Cirolana impressa* Harger. Lateral view of female, enlarged three diameters.
" 3 a. Antennula of another specimen, enlarged twelve diameters.
" 3 b. Antenna of same specimen, enlarged twelve diameters.
" 3 c. Pleon of *C. impressa* as in fig. 4, enlarged five diameters.
" 3 d. Pleopod of the second pair of *C. impressa*, male, enlarged eight diameters.
" 4. Pleon of *Cirolana concharum* Harger ex Stimpson, showing the first five segments in a lateral view, with dotted outline of last thoracic segment and its epimeron, enlarged five diameters.

PLATE II.

Fig. 1. *Cirolana spinipes* Bate & Westwood. Last segment of pleon with uropods, enlarged six diameters.
" 1 a. Leg of the first pair, enlarged eight diameters.
" 1 b. Leg of the fourth pair, enlarged six diameters.
" 1 c. Leg of the seventh pair, enlarged six diameters.
" 2. *Cirolana polita* Harger ex Stimpson. Last segment of pleon with uropods, enlarged six diameters.
" 2 a. Leg of the first pair, enlarged eight diameters.
" 2 b. Leg of the fourth pair, enlarged eight diameters.
" 3. *Cirolana impressa* Harger. Last segment of pleon with uropods, enlarged six diameters.

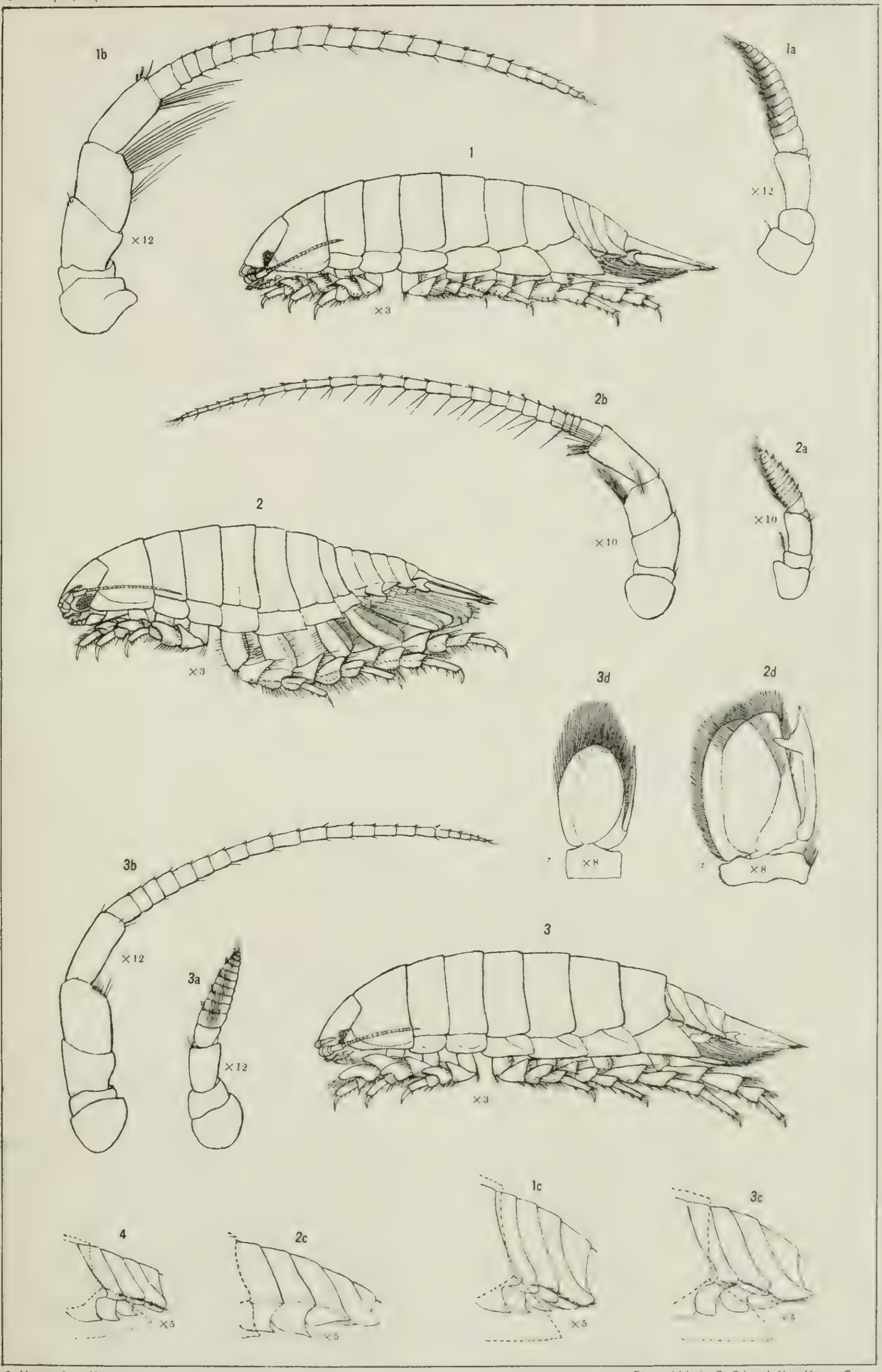
Fig. 3 a. Leg of the first pair, enlarged eight diameters.
" 3 b. Leg of the fourth pair, enlarged eight diameters.
" 3 c. Leg of the seventh pair, enlarged eight diameters.
" 4. *Cirolana concharum* Harger ex Stimpson. Last segment of pleon with uropods, enlarged six diameters.
" 4 a. Leg of the first pair, enlarged eight diameters.
" 4 b. Leg of the fourth pair, enlarged eight diameters.
" 4 c. Leg of the seventh pair, enlarged eight diameters.

PLATE III.

Fig. 1. *Æga incisa* Schiödte & Meinert. Dorsal view of specimen from Station 307, enlarged five diameters.
" 2. *Rocinela oculata* Harger. Dorsal view of specimen from Station 305, enlarged six diameters.
" 2 a. Ventral view of same specimen, enlarged six diameters.
" 3. *Rocinela Americana* Schiödte & Meinert. Dorsal view of female, enlarged three diameters.
" 3 a. Ventral view of same specimen, enlarged three diameters.
" 4. *Rocinela Americana* Schiödte & Meinert. Head and first thoracic segment of male, enlarged three diameters.
" 5. *Syscenus infelix* Harger. Dorsal view of male, enlarged one and one half diameters.
" 5 a. Lateral view of same specimen, enlarged one and one half diameters.

PLATE IV.

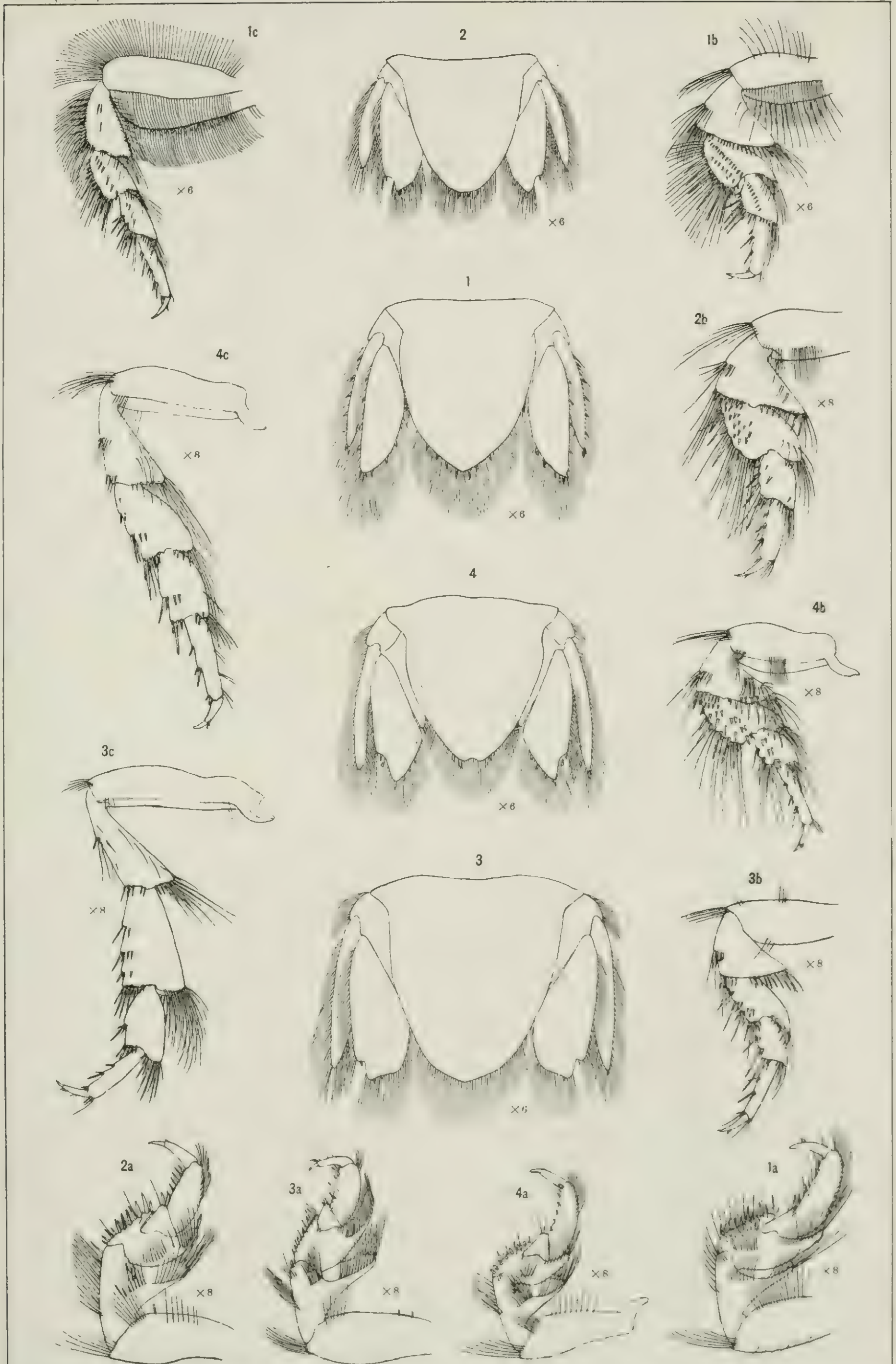
Fig. 1. *Rocinela oculata* Harger. Leg of the first pair from specimen figured on Plate III., enlarged fifteen diameters.
" 2. *Rocinela Americana* Schiödte & Meinert. Leg of the first pair, enlarged ten diameters.
" 2 a. Leg of the sixth pair of the same, enlarged six diameters.
" 3. *Syscenus infelix* Harger. Inferior view of the head, right antenna removed to show the antennula, enlarged eight diameters.
" 3 a. Left mandible of same, enlarged twenty diameters.
" 3 b. Maxilla of the first or inner pair, enlarged twenty diameters.
" 3 b′. Tip of same, enlarged about seventy-five diameters.
" 3 c. Left maxilliped of same, enlarged twenty diameters.
" 3 d. Leg of the first pair of same, enlarged four diameters.
" 3 e. Leg of the fourth pair of same, enlarged four diameters.
" 3 f. Leg of the sixth pair of same, enlarged four diameters.
" 3 g. Pleopod of the second pair of same, male, enlarged four diameters.
" 3 h. Uropod of same, enlarged four diameters.



O. Harger, from Nature.

Photo. Lith. by E. Crisand, New Haven, Conn.

CIROLANA POLITA. C. SPINIPES. C. IMPRESSA. C. CONCHARUM.

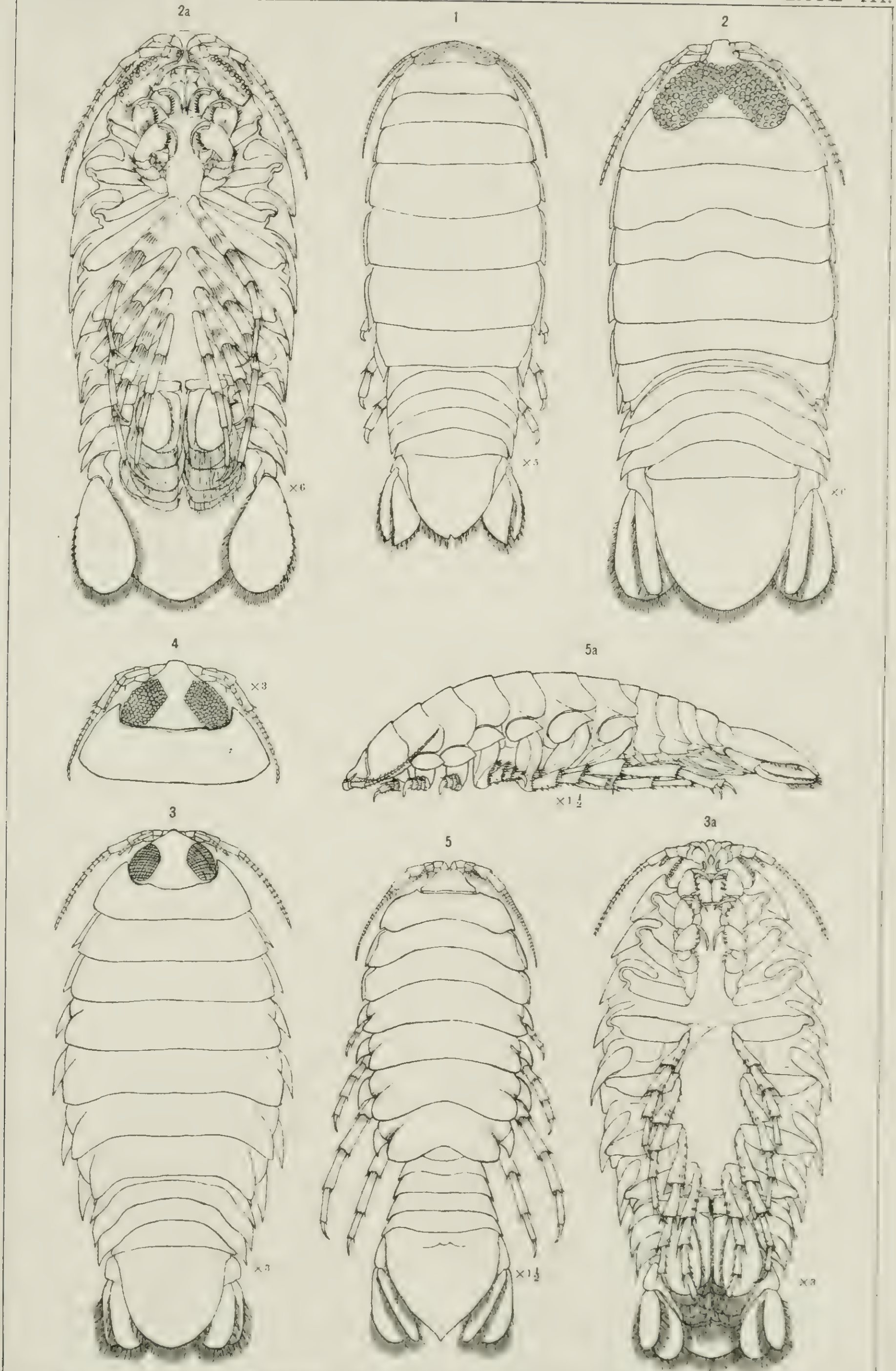


O. Harger, from Nature.

Photo. Lith. by E. Crisand, New Haven, Conn.

CIROLANA POLITA. C. SPINIPES. C. IMPRESSA. C. CONCHARUM.

PLATE III.



O Harger, from Nature

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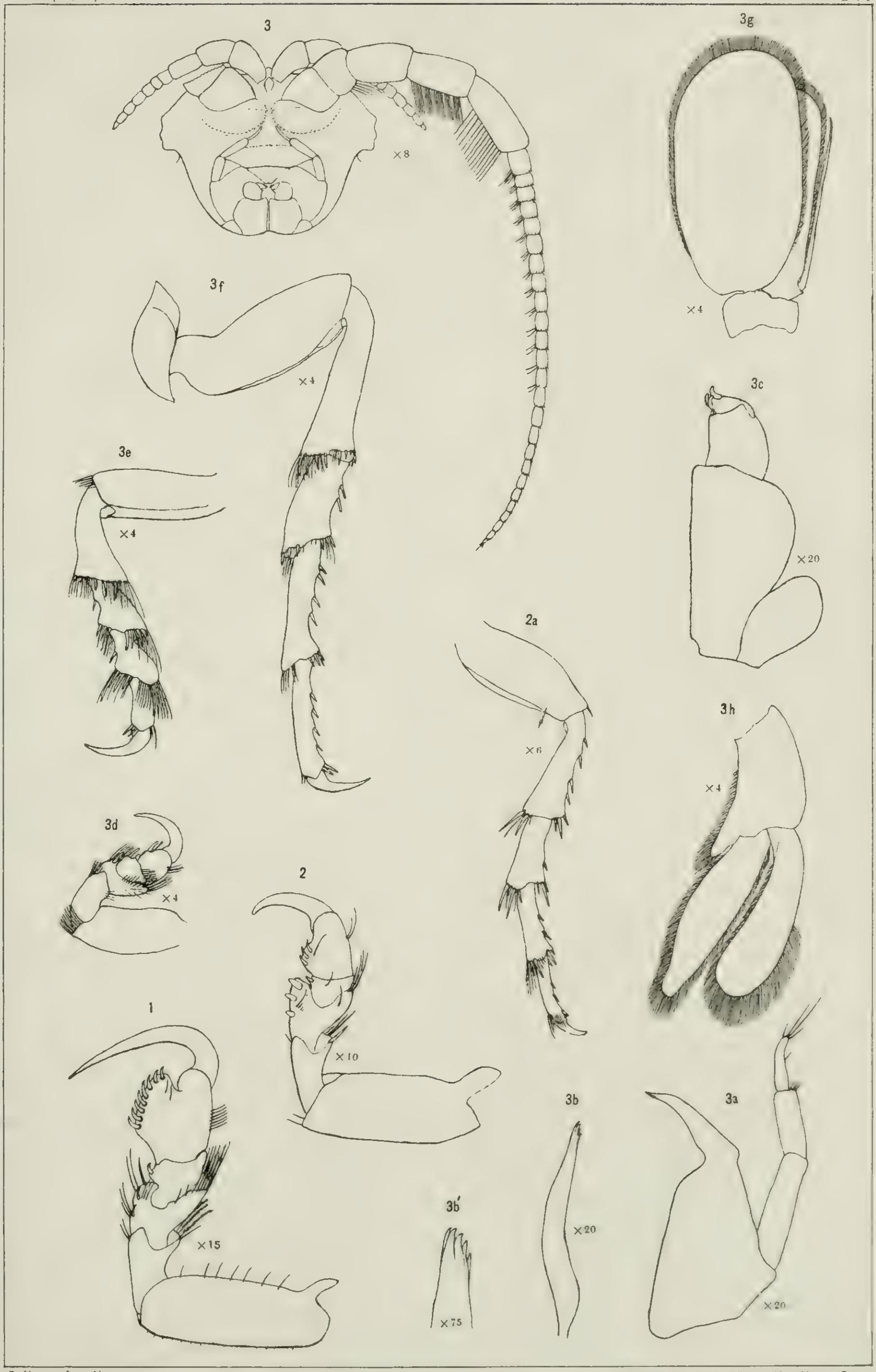
AEGA. ROCINELA. SYSCENUS.



O. Harger, from Nature.

Photo. Lith. by E. Crisand, New Haven, Conn.

ROCINELA, SYSCENUS.

No. 5.—*Reports on the Results of Dredging, under the Supervision of* ALEXANDER AGASSIZ, *in the Gulf of Mexico and in the Caribbean Sea* (1878–79), *by the U. S. Coast Survey Steamer "Blake,"* LIEUT.-COMMANDER C. D. SIGSBEE, U. S. N., *and* COMMANDER J. R. BARTLETT, U. S. N., Commanding.

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XXV.

Supplementary Report on the Blake Cephalopods. By A. E. VERRILL.

THE following paper includes the results of an examination of a small collection of Cephalopods received after my former report had been printed. The specimens are not numerous, but among them there are two very remarkable new genera, of unusual interest.

All the specimens in this lot were taken in the West Indian region, and mostly in rather deep water.

Abralia megalops VERRILL.

Amer. Jour. Sci., Vol. XXIV. p. 364, 1882.

Plate III. Fig. 4.

A small immature specimen occurred at Station 294, in 137 fathoms, off Barbados, 1878–79.

The body is moderately long, pointed posteriorly, with the anterior mantle-edge prolonged into a broad, blunt median angle. Caudal fins large, the base rather large, occupying nearly one third the length of the mantle. Taken together the outline is broad-rhomboidal, and slightly sagittate; the outer angle of the fin is obtusely pointed; the anterior margin is broadly convexly curved, projecting forward somewhat beyond the base. Head rather large. Eyes very large. Arms slender, the dorsal ones shorter than the others, which are subequal. Tentacular arms long, very slender, more than twice as long as the sessile ones. The connective cartilage at the base of the siphon is large, broadest posteriorly, tapering to a blunt point anteriorly, with a central longitudinal furrow, having thickened margins.

The color is whitish, with rather large, well-separated, reddish brown chromatophores, both above and below; a large dark brown spot on the head above each eye.

The basal portion of the arms is destitute of suckers for some distance, then there are two alternating rows of small hooks along the middle; these are followed, distally, by two rows of small oblique suckers, having the horny rim of the orifice armed on the outer or higher side with several long, slender, incurved teeth.

The clubs are small, but distinctly enlarged and bordered by lateral membranes; in the middle portion there is a row of three or four larger elongated hooks, with a few smaller ones in the same row, and a row of suckers alternating with the hooks; outside of these, on each side, there is a row of marginal suckers; at the tip there is a crowded cluster of minute suckers; on the wrist there is a small group of smooth suckers and tubercles.

Length of the mantle, dorsally, 12 mm.; length of body and head, 14 mm.; breadth of head, 5.5 mm.; breadth across fins, 12 mm.; from tip of tail to anterior lobe of fin, 7 mm.; tip of tail to origin of fin, 6 mm.; length of tentacular arms, 15 mm.

The figure is from the type-specimen taken by the U. S. Fish Commission off Martha's Vineyard, Station 1137, in 173 fathoms.

Sthenoteuthis Bartramii (Les.) Verrill (?).

Verrill, Trans. Conn. Acad., Vol. V., p. 223, 1880, p. 288, 1881.
Ommastrephes Bartramii D'Orbigny, Ceph. Acetab., Pl. 2, figs. 11–20.
Steenstrup, Oversigt k. Danske Vid. Sels. Forhandl., 1880, p. 79, fig. 2, p. 81, fig. 3, p. 89.

A fragment of an arm, from a rather large species of *Ommastrephes* or *Sthenoteuthis*, was obtained by Commander J. R. Bartlett. It was brought up on the sounding lead in 607 fathoms, 4¼ miles N. W. ⅝ W. of Sombrero Light, N. Lat. 18° 36′, W. Long. 63° 32′ 30″; temperature of the bottom, 41°.

This fragment is about 60 mm. long and 10 mm. broad at the larger end. It is from the terminal portion of an arm of which the tip had been amputated and healed. The suckers are rather large, on slender pedicles, which arise from swollen elevations on the inner surface of the arm; each margin of the inner face is bordered by a moderately wide, thin, incurved membrane, which is supported by well-marked transverse muscular ridges, which run out from between the bases of the suckers. The suckers are obliquely attached, with very oblique apertures; the basal half of the cup is much smaller than the outer portion, and is separated from it by a distinct constriction; the distal portion is obliquely cup-shaped, with the inner side much narrower than the outer; the margin is supported by a very broad, horny rim; the outer edge of the aperture is surrounded by a circle of 12 to 14 regular, close, very sharp incurved teeth, of which the median one is not distinctly larger than those adjacent; the inner half of the border is armed by numerous, very much

smaller, sharp denticles ; outside of the horny rim the marginal membrane is covered with a regular circle of minute horny plates.

The transverse breadth of this arm-fragment at the thickest end is 9 mm.; across internal face, with the lateral membranes extended, 15 mm.; length of transverse muscular bands of the marginal membranes, 4 mm.; diameter of the largest suckers, 4 mm.; height of cups, 5 mm. Number of larger teeth on the sucker-rings, 14 to 17; of smaller ones on the inner edge of the rim, 8 to 10.

Cheiroteuthis lacertosa Verrill.

Trans. Conn. Acad., V., p. 408, Pl. 56, figs. 1–1 f, 1881; Report U. S. Fish Commission for 1879, [pp. 119, 209,] Pl. 46, figs. 1–1 f, 1882.

A specimen of this rare species, somewhat smaller than the original type-specimen, was obtained. It has both tentacular arms with the clubs in good condition. It agrees closely with the type-specimen, already described in detail, and figured by me, in all its essential characters. In color it differs only in being somewhat paler, and in having rather distinct pale, or whitish, small round spots scattered over the dorsal surface. The row of dark spots along each of the ventral arms is very distinct.

Measurements of Cheiroteuthis lacertosa.

Length of body to dorsal edge of mantle, ...	77 mm.
Breadth of body, ...	14 "
Length of caudal fin, ...	40 "
Transverse breadth across fins, about	30 "
Length of head from dorsal cartilage to base of arms, .	36 "
Breadth of head at eyes, ...	15 "
Length of dorsal arms, ...	60 "
" " " 2d pair, ...	75 "
" " " 3d pair, ...	96 "
" " " 4th pair, ...	153 "
Diameter of dorsal arms at base, ...	4 "
" " " " 2d pair, . . .	5 "
" " " " 3d pair, . . .	5.5 "
" " " " 4th pair, . . .	9 "
Length of tentacular arm, ...	660 "
Length of club, ...	60 "
Its breadth, in the middle	8 "
Diameter of largest suckers of lateral arms, . . .	2 "
" " " ventral arms, . .	1 "

Station 230, in 464 fathoms, off St. Vincent, W. I., 1878–79.

A very large specimen of this species has recently been taken by the U. S. Fish Commission steamer "Albatross," at Station 2074, in 1309 fathoms, N. Lat. 41° 43′, W. Long. 65° 15′ 20″.

NECTOTEUTHIS Verrill, gen. nov.

Sepiolidæ allied to *Stoloteuthis*. Mantle with a free anterior dorsal edge; ventrally forming a sort of shield for the lower surface of the body, and prolonged far forward beyond the eyes, as a broad upturned lobe. Fins large, thin. Eyes large. Arms united by a web of considerable extent. Sessile arms, in the type-specimen (probably male) with the suckers on the distal part very minute, conical, sessile on the ends of stout tapering or conical pedicels; those on the proximal part normal, small, oblique, with slender pedicels. Pen not observed, perhaps wanting. Club of tentacular arms with numerous minute, subequal suckers, in many rows.

Nectoteuthis Pourtalesii Verrill.

Plate III. Figs. 1-1b.

A very small species, remarkable for its short, thick body; the great size of the ventral shield, which extends forward beyond the bases of the ventral arms; and the large conical sucker-pedicels, surmounted by minute suckers, on the distal half of the arms.

Body short, higher than broad, and well rounded behind; dorsal surface convex; the free mantle border is nearly transversely truncated, with a slight lobe in the middle; sides, below the fins, compressed, nearly vertical. A large ovate, convex shield occupies nearly the whole ventral surface, extending backward nearly to the posterior end, covering the whole width in the middle, and extending forward far beyond the lateral and dorsal mantle-margins, and to the anterior portion of the head; the anterior margin of the ventral shield is curved upward, leaving a deep concavity within; this portion of the ventral shield conceals and protects the entire lower surface of the head and siphon; on the sides, the margin recedes in such a way as to leave the large, prominent eyes exposed. The fins are attached above the middle line of the body; moderately large, very thin and delicate, transparent, except at base, with the margin undulated in the preserved specimen; the bases of the fins extend forward close to the margin of the mantle and backward about half the length of the body; the anterior end is evenly rounded, forming nearly a semicircle. Head large, as broad as the body, narrowed in front. The eyes, which are very large and prominent, occupy nearly the whole of the sides of the head; eyelids thin but distinct; pupil round. Arms small, slender, unequal in size and length, and connected together for some distance by a basal web, which extends farthest between the dorsal arms and is wanting between the ventral pair. The web has an outer fold, as it passes the second pair of arms, so that the latter appear to be inside the edge of the web. Dorsal arms much shorter than the lateral and ventral pairs, the free tips projecting but little beyond the edge of the web. The arms increase successively in length from the dorsal to the ventral pairs, which scarcely exceed the third pair, but all have the same kinds of suckers, in

two alternating rows; the free portion is slender, rounded externally, and tapers to a slender tip; on the distal half, the sucker-pedicels are long, very prominent, conical, larger than the suckers, and tapering toward the tip, which terminates in a minute conical sucker, without any constriction between it and the pedicel; of these there are ten or more pairs on the lateral and ventral arms, and four or five pairs on the dorsal arms; the length of the sucker-pedicels and suckers together is greater than the diameter of the arms; on the basal half of the arms the suckers are of the ordinary structure, as in *Rossia;* they are small, with small apertures, oblong, obliquely attached, on short, slender pedicels, which are surrounded by submarginal swellings of the arm-surface. Of these normal suckers there are nine to ten pairs on the lateral and ventral arms; of these two or three, at about the sixth or seventh pair, on the lateral arms, are distinctly larger than those before or beyond them. One or two of intermediate form connect the normal with the specialized suckers. The dorsal arms are united together along their inner surfaces, which turn toward each other, for some distance from the base by a thickened membranous fold, which forms a sort of pocket or sinus between the arms, probably for sexual purposes. Tentacular arms are long, slender, triquetral, tapering distally; club small, curled, a little wider than the portion of the arm just below it, covered with numerous very minute suckers, arranged in many rows.

Siphon relatively large and prominent, projecting forward in front of the bases of the ventral arms.

Measurements of Nectoteuthis Pourtalesii.

Length to tip of longest sessile arm, ...	24 mm.
" dorsal edge of mantle, ...	11 "
" ventral edge of mantle, ...	17 "
" bases of lateral arms, ...	17 "
Breadth of body (or head), ...	10 "
Diameter of eyeball, ...	6 "
Longitudinal extent of fin, ...	10 "
Breadth from base to outer edge, ...	6 "
Length of its insertion, ...	7 "
" dorsal arms, ...	6 "
" second pair, ...	7.5 "
" third pair, ...	8.5 "
" ventral arms, ...	10 "
" tentacular arms, ...	30 "
" club, ...	3 "

Color of the dorsal and lateral surfaces of alcoholic specimen dark reddish brown, due to a large number of chromatophores, which extend but a short distance beyond the bases of the fins; sides of the head, above the eyes, darker brown; ventral shield dark purplish brown, caused by great numbers of very minute chromatophores; its margin is surrounded by a pale band; arms and

sucker-pedicels yellowish white, with a few small brown chromatophores; the outer portion of the fins is yellowish white and probably transparent when living.

The sex of the single example was not determined. Possibly the remarkable suckers and pedicels on the distal half of the arms may be due to hectocotylization, peculiar to the male. In this example the dorsal arms are closely united together, to near the tips, and within the web the basal portion is much thickened and the suckers are crowded and partially concealed by the incurved margins of the arms, and by their facing strongly toward each other. This may also be a sexual character.

Station 295, in 180 fathoms, off Barbados, Blake Expedition, 1878–79.

This curious species has a striking general resemblance to *Stoloteuthis leucoptera* V., from deep water off the New England coast. It is readily distinguished by the free dorsal edge of the mantle, by the ventral shield projecting much farther forward, and by the remarkable form and structure of the distal sucker-pedicels and suckers. The fins are smaller, and the arms more slender. It is probable that the unique specimen is a male, and that some of the peculiar features of the arms and suckers may be only sexual.

Rossia brachyura Verrill, sp. nov.

Plate III. Fig. 2.

A small species with a very short body, large fins, and very small suckers, in two rows on the basal part of the arms, but in four rows distally.

Body unusually short, scarcely longer than broad, broadly rounded and somewhat emarginate posteriorly; mantle-edge advancing in a broad obtuse lobe dorsally, extending farther forward with a slight median emargination ventrally. Fins very large and prominent, the insertion equal to about three quarters the length of the body, the outer margin thin and broadly rounded, the anterior lobe free, rounded, and projecting forward beyond the mantle-edge, the posterior margin also free and projecting back somewhat as a rounded lobe, reaching nearly to the end of the body. Eyes large, with the lower lid slightly thickened. Sessile arms rather long, subequal in length, the dorsal ones a little shorter than the others. The suckers are similar in size and arrangement on all the sessile arms; on the basal third they are arranged in two rows; farther out they form four rows, which become crowded toward the tips. The suckers are very small, oblique, deep urceolate, with small apertures; they decrease regularly from near the middle to the tips of the arms. Tentacular arms moderately long and stout; club rather large, distinctly thickened, with a high dorsal keel; suckers very numerous and small, campanulate, crowded in about 16 rows, decreasing gradually in size from the upper to the lower edge, where they become very minute.

Color, in alcohol, pale purplish brown, with numerous small, unequal chromatophores, beneath as well as above; arms paler; fins whitish.

Length of body, above, 18 mm.; of body and head, 27 mm.; breadth of body, 15 mm.; length of insertion of fin, 12 mm.; its greatest length, front to back edge, 16 mm.; height, base to tip, 9 mm.; length of dorsal arms, 15 mm.; 2d pair, 17 mm.; 3d pair, 18 mm.: 4th pair, 17 mm.; of tentacular arms, 28 mm.; of club, 12 mm.; diameter of largest suckers of lateral arms, 60 mm.; of largest suckers of tentacular clubs, 12 mm.

Station 148, in 208 fathoms, off St. Kitts, 1878–79. One female.

Heterotheuthis tenera Verrill.

Amer. Jour. Sci., XX., p. 392, 1880; Bulletin Mus. Comp. Zoöl., XIII., p. 103, Pl. 3, figs. 5–5 b; Pl. 7, figs. 2–2 d, 3–3 b, 1881; Trans. Conn. Acad., V., p. 357, Pl. 46, figs. 2–2 d, 3–3 b, Pl. 47, figs. 5–5 b, 1881; Report U. S. Fish Com. for 1879, [p. 175,] Pl. 33, Pl. 34, fig. 1, 1882.

One specimen (♀), from Station 148, in 208 fathoms, off St. Kitts.

Octopus tuberculatus Blainv. ?

A species with long arms, a short basal web, and peculiar branched cirri above the eyes and scattered over the back. Probably young.

The body is moderately large, oblong, swollen below, well rounded behind. Head about as broad as the body, with large prominent eyes. Upper surface of the body and head thickly covered with rather small, low warts, which also extend along the dorsal sides of the arms and on the basal web; scattered over the upper surface of the body and head are prominent cirri, some of which are simple and tapered, while others are divided into three to five digitate lobes or branches; of these, two are situated in the median dorsal line, four form a quadrangle on the dorsal surface of the body, and two are situated on each side of the body in line with the eyes; on the head, one is situated in the median dorsal line between the bases of the dorsal arms; one much larger and more complicated than the others is situated above each eye; this may have seven or eight slender branches; the eyelids are covered with prominent warts; the lower surface of the body is paler and smoother, with only minute inconspicuous warts, more evident anteriorly. Siphon moderately large, strongly tapered. The arms are long and rather slender, tapering to slender tips; they are subequal in size and length, the ventral ones a little smaller and shorter; the suckers are rather small, the two rows well apart; the two basal ones are much smaller than the succeeding ones and stand nearly in the median line. The basal web extends about one third the length of the arms; the arms are bordered for some distance by a thin, narrow, marginal membrane on each side. The hectocotylized arm is but little shorter than its mate, and tapers to an acute but modified tip; along the border of the arm there is an incurved marginal groove formed by the narrow, inflexed marginal membrane, which terminates

in a minute conical papilla at the base of the modified tip ; this is very small, narrow, tapered, acute, with thickened margins and a narrow median groove, which is crossed by numerous, very small, transverse furrows. Color of the upper surface of the body, head, and basal web pale purplish brown, mottled and streaked with darker ; the color is due to numerous minute purplish chromatophores, among which there are a few larger, more definite, dark brown ones ; the warts appear to have been paler ; the cirri are yellowish white without chromatophores. The lower side of the body, head, siphon, and arms, with the inner surface of the arms, is yellowish white, having very few chromatophores, among which are a few very definite, small, dark brown ones.

Length of body, 17 mm.; of body and head, 22 mm.; breadth of body, 13 mm.; of head, 13 mm.; breadth of web, from mouth, 13 mm.; length of second pair of arms, 52 mm.; of first pair, 50 mm.; of third pair, 51 mm.; of the ventral arms, 50 mm.; of the hectocotylized arm, 45 mm.; length of the modified tip, 2.5 mm.; its breadth, 1 mm.

Stations 278, in 69 fathoms, and 296, in 84 fathoms, off Barbados, 1878–79. Three specimens.

Octopus pictus Verrill, sp. nov.

Plate III. Fig. 3.

Body relatively large, oblong, smooth, bluntly rounded posteriorly. There is no constriction between the head and body, and the head is rather broader than the body; eyes large, rather prominent. There is a single small rounded wart over each eye. Web between the arms rather small, thin, extending about one fourth the length of the arms, narrower between the ventral arms. Arms moderately long, nearly equal in size and length. Suckers relatively large, in two rows, not crowded ; the two basal suckers are small, nearly in the middle line, the innermost ones forming a regular circle around the mouth. The color is peculiar; over the entire surface of the body, above and below, and on the upper surfaces of head, arms, and web, there are numerous rather large distinct, round, reddish brown or dark brown spots, usually with a darker central point ; between these there are numerous minute, lighter colored chromatophores ; inner surfaces of the web and arms yellowish white.

Length of the head and body, 8 mm.; breadth of body, 6 mm.; length of the arms, 16 mm.

Station 142, in 27 fathoms, Flannegan Passage, and Station 278, in 69 fathoms, off Barbados, 1878–79. One young specimen from each place.

Although the specimens are probably the young of some larger species, it is unlike any of the described West Indian forms known to me in its peculiar ocellated coloration and the very smooth surface of its body, with only a single wart above the eye.

OPISTHOTEUTHIS Verrill, gen. nov.

Body broad, depressed, closely united to the brachial web except at the posterior end, which projects slightly. Fins long, attached at about the middle of the body, near the dorsal surface; bases wide apart, each supported by a distinct transverse cartilage. Siphon small, projecting slightly from beneath the posterior end of the body, and directed backward, with a very small aperture. Head as broad as the body; eyes large. The lower surface of the head and body wholly attached to the brachial membranes. Arms subequal, united together to near their tips by a very broad, thick, soft web, which leaves only the inner surface of the arms exposed; suckers in a single row, those toward the base of the arms largest. On each side and alternating with the suckers is a row of small, tapered cirri; these commence in a rudimentary form between the first two suckers, and continue from there to the tips.

Opisthoteuthis Agassizii Verrill, sp. nov.

Plate I. Fig. 1. Plate II. Fig. 1.

The body is broad, depressed, rounded posteriorly, and with the head is wholly adnate to the web connecting the arms, except at the posterior end behind the fins, where it is slightly free and overhangs a little; the siphon projects backward beneath the posterior end in the groove thus formed; the branchial opening appears to have been small, partially surrounding the siphon, but the membranes in this region are much mutilated, so that its form and extent cannot be determined. The fins are large, thin, wide apart, elongated, oblong ovate in form, the outer end bluntly rounded, each fin is supported by a separate internal cartilage, of which the inner end is broadest and thick, while the outer end extending into the free portion of the fin is much thinner, lanceolate, tapering to a blunt point; this cartilage is situated much nearer to the posterior than to the anterior edge of the fin and does not extend much beyond its middle, leaving the terminal third thin and flexible. The head is about as large and as broad as the body; the eyes are very large and occupy the entire sides of the head. As seen from above the arms are concealed except at the tip by a thick, soft web, which unites them together and unites them closely to the sides of the head and body. The integument of the entire upper surface is very soft and flabby, and appears to have been smooth, although it is much wrinkled in the alcoholic specimen; the web between the arms extends to near the end, leaving only about one fifth free, and this portion is bordered by a membranous fold along each side. The web consists of an outer and inner portion, separated by considerable thickness; the inner membrane arises from the inner surface of the arms, which projects but little above it. The arms are rather large and moderately stout along the middle portion, much narrowed toward the bases, which are not in contact; the free ends are rather slender,

compressed, with the tips attenuated; the first five suckers are much smaller than those that follow; the next five or six suckers are the largest; they decrease to about the tenth, and then become larger opposite the edge of the web, finally diminishing gradually to the tips; the cirri, which alternate with the suckers on each side, are widely separated from them along the middle of the arms; they are small, slender, tapered, acute, dark purplish brown in color; those toward the tip and close to the base of the arms are very small. The beak is moderately large, black. The buccal membrane is covered with small verrucæ.

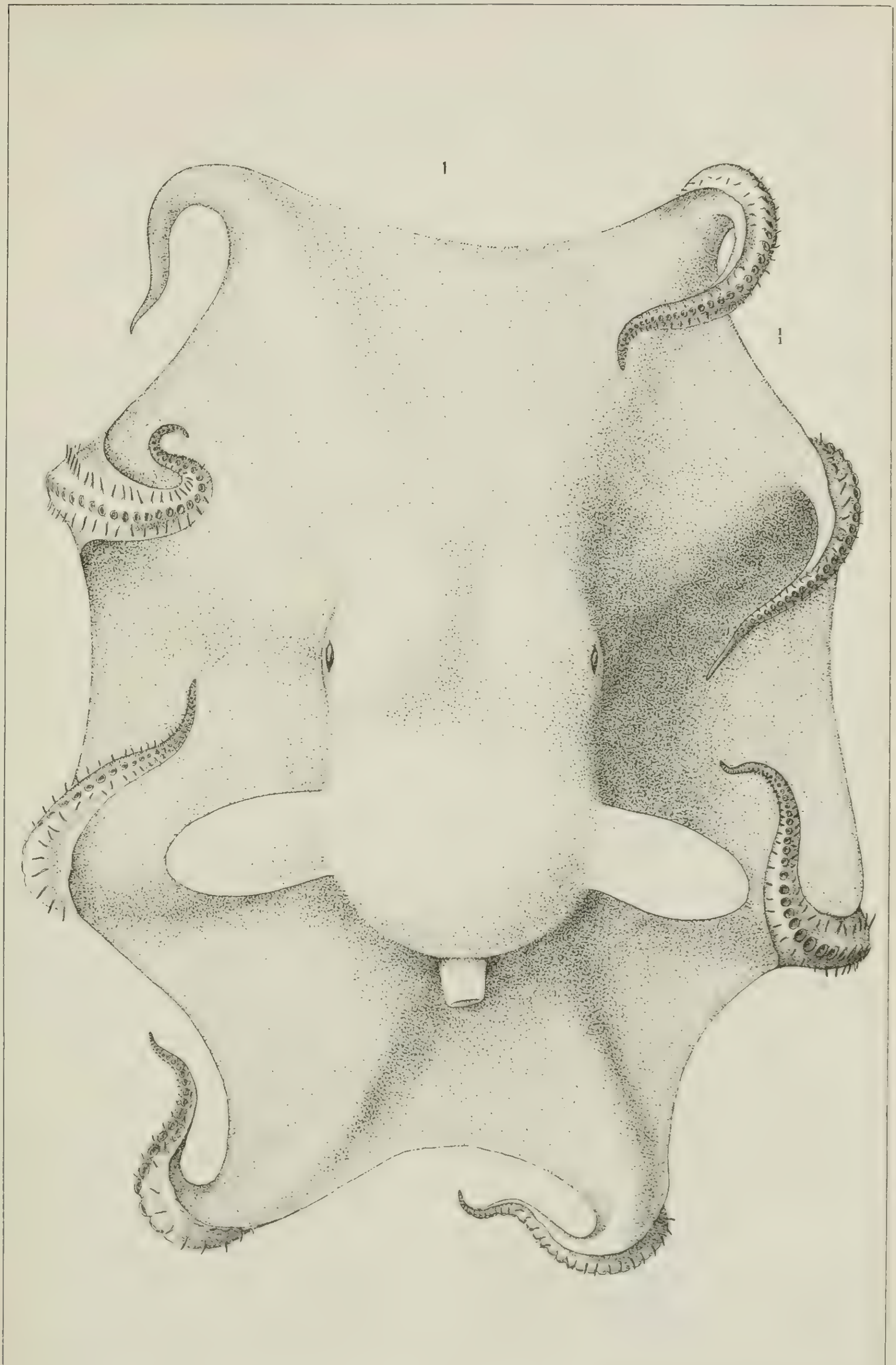
Color of the upper surface chocolate-brown, with small scattered roundish spots of yellowish white. Fins paler brown. Inner surface of the web dark chocolate-brown. Inner surface of the arms much paler than the web.

Length of body and head, to base of arms, 60 mm.; breadth of body, 50 mm.; breadth of head across eyes, 52 mm.; extreme breadth across fins, 105 mm.; from base of fin to tip, 30 mm.; anterior to posterior edge, 17 mm.; diameter of eyes, 25 mm.; breadth of interbrachial web, from mouth, 75 mm.; length of dorsal arms, 130 mm.; of lateral arms, 120 mm.; of ventral arms, 130 mm.; greatest breadth of dorsal arms, 9 mm.: diameter of largest suckers, 3 mm.; length of cirri, 2 to 3 mm.

Station 260, in 291 fathoms, off Grenada, Blake Expedition, 1878–79.

This remarkable species differs widely from any hitherto described. It is more closely related to *Stauroteuthis sertensis* than to any other known species; from the latter and from *Cirrhoteuthis* it differs in having the body and head closely adnate to the brachial membranes so as to entirely conceal the ventral portions; in the posterior position of the siphon; and in the arrangement of the cirri on the inner surface of the arms. The fins appear to be larger and more highly developed than in either of the genera referred to. The transverse supporting cartilages are not united across the back, as they appear to be in both the related genera. The arrangement of the web between the arms appears to be unlike that of *Stauroteuthis*, but the only known specimen of the latter was in such a poor state of preservation as to render this statement unreliable. Perhaps the most remarkable characteristic of this species is the posterior position of the siphon and branchial opening, a position which is rendered necessary by reason of the close attachment of the head and body to the brachial membrane. The condition of the internal parts of the specimen is such as to render it impossible to determine the precise character and position of the branchial opening and gills. Only one specimen was obtained, and this is probably a female, for no evidence of hectocotylization can be detected on any of the arms, all of which are well preserved.

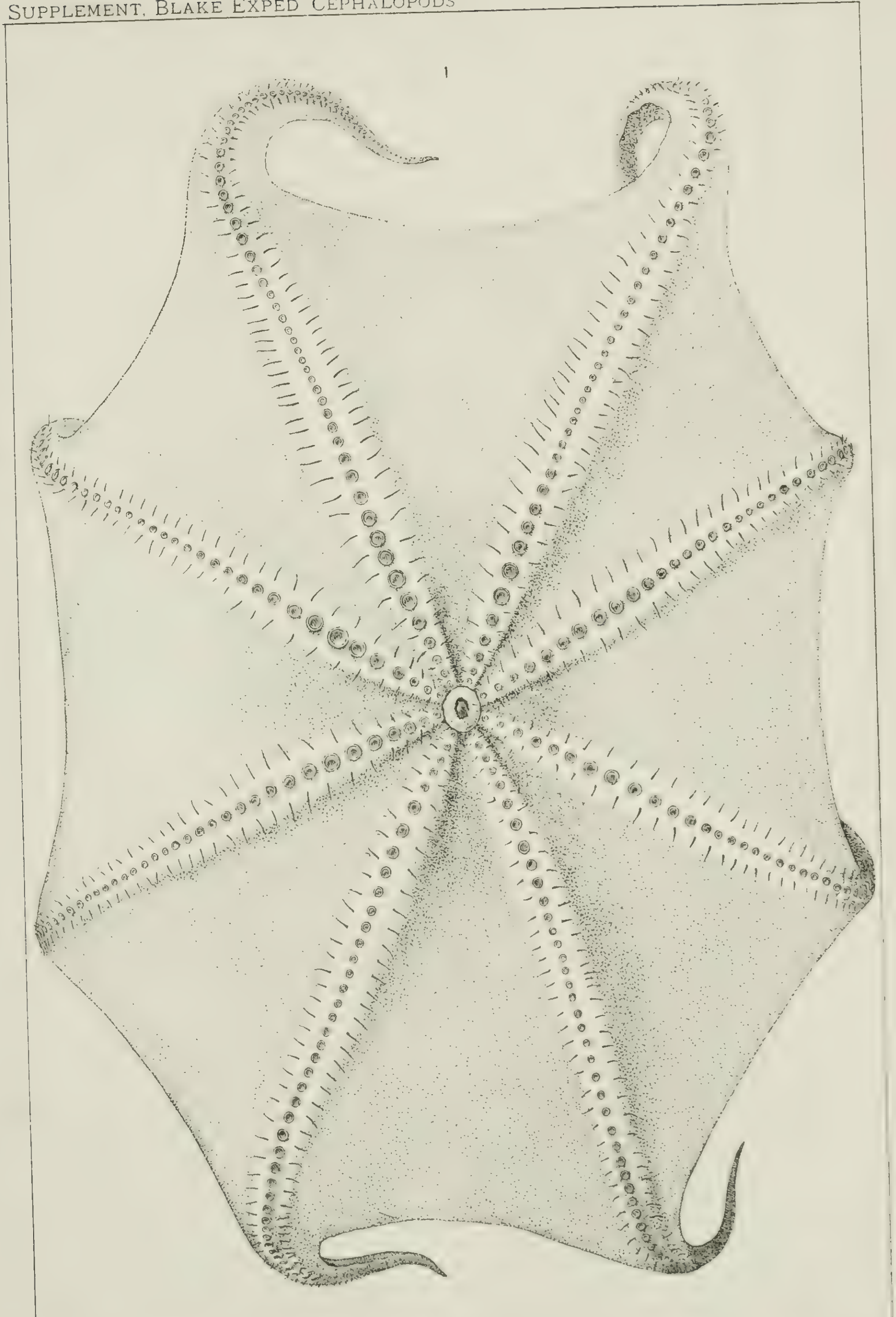
New Haven, October, 1883.



J. H. Emerton, from Nature.

Photo. Lith. by L. S. Punderson, New Haven, Conn.

OPISTHOTEUTHIS AGASSIZII VERRILL.



J. H. Emerton, from Nature

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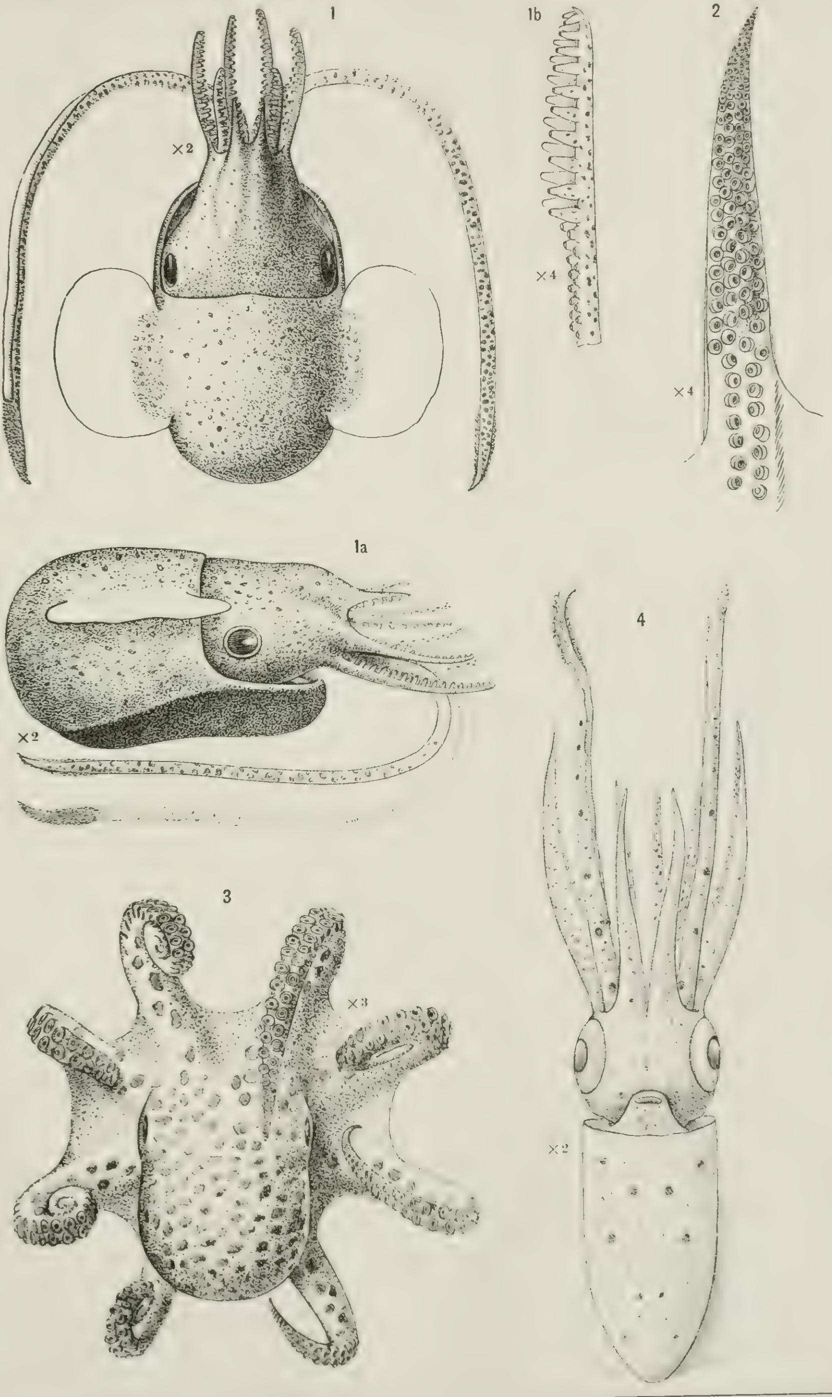
OPISTHOTEUTHIS AGASSIZII VERRILL.



J. H. Emerton, from Nature.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Opisthoteuthis Agassizii* Verrill. Dorsal view. Natural size.

PLATE II.

Fig. 1. *Opisthoteuthis Agassizii* Verrill. Ventral view, showing the arrangement of the suckers and cirri. Natural size.

PLATE III.

Fig. 1. *Nectoteuthis Pourtalesii* Verrill. Dorsal view. Enlarged two diameters.
" 1 a. The same. Enlarged two diameters.
" 1 b. The same. Left arm of the fourth pair. Side view. Enlarged four diameters.
" 2. *Rossia brachyura* Verrill. Left arm of the second pair. Front view. Enlarged four diameters.
" 3. *Octopus pictus* Verrill. Dorsal view. Enlarged three diameters.
" 4. *Abralia megaptera* Verrill. Ventral view of the type-specimen from Station 1137, in 173 fathoms. Enlarged two diameters.

No. 6. — *Descriptions of Two Species of Octopus from California.* By A. E. VERRILL.

IN the following paper the large *Octopus punctatus*, which inhabits the Pacific coast, from San Francisco to Sitka, is described and figured more fully than hitherto. A new species, known to the author for many years, is described under the name of *O. bimaculatus*, a name intended to recall the presence of two large dark spots, one in front of each eye, near the bases of the arms. This species ranges from San Diego to Panama, and perhaps even farther south.

Octopus punctatus GABB.

Octopus punctatus GABB, Proc. California Acad., II., p. 170, 1862.
DALL, Proc. California Acad., III., p. 243, fig. 27 (dentition), 1866.

Plate IV. Plate V. Fig. 2.

Body in preserved specimens more or less ovate, or depressed pyriform, broadly rounded behind and narrowed toward the neck; upper surface of the body and head covered with a soft lubricous integument, which, in the best preserved examples, is strongly and irregularly longitudinally wrinkled, but these wrinkles can be easily smoothed out by the fingers, leaving only slightly thickened, irregular patches and blotches, which are of a darker brown color than the rest of the surface ; similar, slightly raised, darker spots, of smaller size, are numerous on the web and outer surface of the arms ; at the posterior end of the body the wrinkles are more conspicuous, and often give rise to prominent irregular folds, concentric to the body ; these appear to have more persistency than those of the dorsal surface, but as they can be nearly smoothed out, they probably appear and disappear during life, according to the state of contraction of the skin, as modified by the temper of the animal. The entire lower surface is smoother and paler, but shows small, irregular, scattered brown blotches, largest at the sides. The head is of moderate size, with prominent eyes ; above each eye are two large, prominent, compressed or angular, soft cirri, blunt at the tip, but not lobed ; the most anterior of these is opposite or in advance of the centre of the eye, the other is farther back ; around the bases of these cirri, and between them and the eyelids, there are numerous small, unequal, irregular, rounded and compressed warts, which stand somewhat in lines radial to the eye. The siphon is large and long, gradually

tapered. The arms are, in normal specimens, subequal in size, very long, not very stout at base, and very slender toward the tip ; the two lateral pairs are nearly equal, and a little longer than the dorsal ones ; the ventral arms are slightly smaller at base than the others, and about equal in length to the dorsals, or sometimes slightly shorter. The web between the arms is broad and thin ; it is widest between the lateral arms, where it is nearly one fourth as wide as the arms are long, and narrowest between the ventral ones ; between the dorsal arms it is nearly as wide as between the laterals. The web extends as a lateral membrane along the sides of all the arms, but it is widest and extends farthest along the posterior margin of the dorsal and lateral arms and along the anterior margin of the ventrals. Along these margins the membrane can be traced nearly to the ends of the arms. On the anterior sides of the dorsal arms, and on the posterior margins of the ventral ones, the web rapidly narrows, and does not run very far out as a distinct fold, recognizable in preserved specimens. The sucker-bearing face of the arms is not very broad, the breadth of the arms being usually less than the depth, toward the base. The arms are stoutest about opposite the edge of the web, the portion nearer the mouth gradually narrowing. The suckers nearest the mouth are small and elevated, not very close together, alternating, but not standing far out of the median line ; they gradually increase in size, to about the sixteenth or eighteenth, which are within the border of the web, where they attain their full size ; the largest-sized suckers, in the male, continue for some distance beyond the edge of the intermediate web without much change in size ; they are of nearly equal size on the three upper pairs of arms, but somewhat smaller on the ventral ones. Farther out the suckers very gradually diminish in size, becoming very small and very numerous toward the tips. The larger suckers are broad and moderately elevated, with a wide rim and a deep, crenulated central pit, from which strongly marked grooves radiate to the rim. The largest suckers have from 30 to 35 primary grooves that reach the margin of the central pit ; many of these fork once, or even twice, toward the outer margin. The beak is strong and black.

The two large males examined have the third right arm hectocotylized, but not very conspicuously so. A well-marked membranous fold, of moderate breadth, runs from the web along the posterior edge of the arm nearly to the tip ; its inner surface is white and smooth, and naturally curls inward, thus forming a groove, which, at a small, acute, conical papilla, situated at the base of the terminal organ, passes into the furrow of the latter. This organ is relatively small, narrow, rather long, tapering to the tip ; its inner surface is flattened or concave, forming a groove where the margins are incurved. In the best preserved specimens the groove is covered internally, especially near its base, with small, soft, granule-like warts, or papillæ, in about six longitudinal rows, but there are no distinct transverse partitions. The hectocotylized arm, in one of the specimens, had 107 suckers, the distal ones being very small.

The general color of preserved specimens is, as in most species, dull purplish or dark brown on the upper and outer surfaces, paler and more yellowish on

the lower surfaces and on the inside of the arms and web. The color varies much, as in all other cephalopods, according to the mode of preservation, strength of the alcohol, etc. In the best preserved specimens there are irregular, ill-defined blotches and spots of darker purplish brown, often longitudinal in direction, scattered over the upper surfaces of the body, head, and web, and on the sides of the body, beneath. Between these blotches the surface is rather thickly sprinkled with small, dark brown chromatophores.

In life, the color seems to be very changeable. Mr. A. Agassiz has sent me two colored drawings made by him in 1859, from a living specimen taken in the Gulf of Georgia, W. T., and kept in confinement. In one of these drawings the color of the dorsal surface of the body, which is represented as nearly smooth, is purplish red, mottled and streaked with dark brown and with a longitudinal band of brown along the sides, running back from the eyes; the upper and front sides of the web and arms are dull purplish red, irregularly mottled with dark brown; the bases of the ventral arms, with the web between them, and the lower surfaces of the head, have a lighter orange tint. In the other drawing (a side view) the whole surface of the body and head is represented as covered with large and prominent, irregularly wavy folds and ridges, separated by deep wrinkles; the folds are larger posteriorly, but project as irregular warts, both on the back and on the ventral surfaces. The colors of the body and head, in this figure, are dark and rather bright; the upper parts are mottled and streaked with lake-red, dull orange, dark brown, and grayish green, the dark brown and red tints predominating; the lower surfaces are lighter, but similarly mottled, with the orange and lake-red tints most conspicuous; the siphon and edges of the gill-opening are orange-yellow, the latter bordered with dark brown; eyelids brownish red; eyes silvery.

According to the drawings referred to, the body, in life, is swollen and pyriform or ovate, much broader and thicker than the head. In one of the figures there appears to be a membranous fold running along the sides and forming a posterior prominence at the end of the body; in this figure the membranous folds along the sides of the arms are represented as much wider and extending nearer to the ends than in the preserved specimens.

Mr. William H. Dall, who has observed this species in life, furnishes the following notes on its habits: "When angry the horn over the eye is erected, the arms coil together, the eye dilates, and the body quivers with rage. The muscles keep up a squirming motion, but I have never seen any approach to the dark color figured by Chenu as characteristic of the angry *Octopus vulgaris* of the Mediterranean, nor any such elevated longitudinal ridges. The suckers project or are retracted according to the mood of the animal; their outer edge expands when about to seize hold, and contracts after getting hold of anything. In very large individuals the extremities of the arms are long and much attenuated. I suppose they can adjust their shape to their quarters, but when in motion the body is round and always *on top* and the oral disk is invisible. It never willingly turns its mouth up, and when forced to do so clinches its arms, like a fist, over it. With death comes flaccidity and flattening. One with a

body 8 inches in diameter had the arms 16 feet long. They shrank much in alcohol."

Measurements of Octopus punctatus Gabb, in millimeters.

	Nat. Mus., No. 33076 ♂.		M. C. Z., No. 62 ♂.	
	Right side.	Left side.	Right side.	Left side.
Length of body to eye,			229	
From edge of mantle to tip of tail (below),			153	
Breadth of body,			140	
Breadth of head, at eyes,	70		66	
Breadth of head, at base of arms,	82.5		89	
Diameter of eyeball,	25.5		28	
Eye to web between ventral arms,	203			
Eye to web between 3d and 4th arms,	165			
Eye to web between 2d and 3d,	178			
Eye to web between 1st and 2d,	153			
Mouth to edge of web between dorsal arms,	114		165	
Mouth to edge of web between 1st and 2d,	178		216	
Mouth to edge of web between 2d and 3d,	178		216	
Mouth to edge of web between 3d and 4th,	216		229	
Mouth to edge of web between ventral arms,	153		114	
Length of siphon, lower side,	70		106	
Diameter of siphon, near base,	38		33	
Diameter of siphon, at tip,	13		15	
Length of dorsal arms (1st pair),	485	672	915	953
Length of lateral arms (2d pair),	648	699	965	978
Length of lateral arms (3d pair),	533	673	737	965
Length of ventral arms (4th pair),	737	635	838	915
Breadth of 1st pair of arms,	32		25.5	
Breadth of 2d pair of arms,	35.5		25.5	
Breadth of 3d pair of arms,	38		25.5	
Breadth of 4th pair of arms,	32		21.5	
Diameter of largest suckers, 2d and 3d pairs of arms,	20 to 25.5		18	
Diameter of central pit,	6		3	
Diameter of largest suckers on dorsal arms,	19 to 23		18	
Diameter of largest suckers on ventral arms,	19 to 20		15	
Length of terminal organ on hectocotylized arm,	71		71	
Diameter at base,	6		6	

This species has a wide range along the Pacific coast. It extends from San Francisco to Sitka, Alaska. On the coast of Alaska it is smoked and dried by the Indians as an article of food. In the markets of San Francisco it is often sold fresh, to the French and other foreigners, for food.

Octopus bimaculatus Verrill, sp. nov.

Plate V. Figs. 1, 1 a. Plate VI.

Size moderate, body relatively large, elongated pyriform, enlarged posteriorly, somewhat depressed in alcoholic specimens. Upper surface everywhere covered with prominent, unequal, raised warts, usually conspicuous in preserved specimens, except in those which are unusually flaccid, in which they sometimes become low, rounded, or flattened, but do not entirely disappear. On the ventral surface the warts are much smaller and less conspicuous. Head large, not so broad as the body, from which it is separated by a slight constriction; sides of the head about the eyes prominent. Eyes large. Upper surface and sides of the head conspicuously warted like the body, or more coarsely than the body; above and a little behind the eyes there is one large, conical, warted cirrus; in front and around this, above the eye, there are numerous large, prominent warts, some of them larger than those on the general surface. Arms rather long, moderately stout, united at the base for a considerable distance by a strong thick web, the upper surface of which is strongly warted, like the head and body. The web is much more extensive between the dorsal arms than between the ventral ones, usually broadest between the second and third pairs. The lower surface of the web and the sides and ventral surface of the arms are covered with very numerous, crowded, minute, conical or granule-like warts, which often appear to be arranged in small patches or clusters separated by smoother, paler, reticulated lines or wrinkles. Arms unequal, the dorsal pair considerably smaller and shorter than the others. The second and third pairs are very nearly equal in size and length. The fourth pair is a little smaller and shorter, but considerably longer than the dorsal pair. The arms are rounded trapezoidal toward the base, with the sucker-bearing face broad and the dorsal surface well rounded; the membrane along the sides of the arms in continuation of the web is usually narrow and inconspicuous, and can often be traced only for a short distance. The suckers toward the bases of the arms are large, broad, saucer-shaped, with strong radiating grooves, about thirty in number, and with a large and deep central pit. Margin much expanded, with two borders, the outer one soft and finely crenulated, the inner one divided into lobes by radiating grooves. In some males examined, one sucker within the border of the web is very much larger than any of the others on the second and third pairs of arms. This enlarged sucker is the twelfth from the base, and in the posterior row on each arm. One male of large size has the corresponding sucker only a little larger than the adjacent ones, but the two pairs of lateral arms in the males have ten or twelve suckers (from about the tenth to the twentieth suckers) mostly within and near the edge of the web decidedly larger than the corresponding ones on the dorsal and ventral arms. Beyond the edge of the web the suckers rapidly diminish in size, and on the distal half become relatively small, and gradually decrease to the very small ones which cover the attenuated tips. The large suckers toward the base of

the arms are but little elevated, and have very broad bases ; they alternate regularly, and their borders are nearly or quite in contact. The three suckers next the mouth on each arm are nearly in one line ; the smaller inner ones forming a regular circle around the mouth.

In the male, the right arm of the third pair is hectocotylized. This arm is decidedly shorter than its mate, and tapers much more rapidly to the tip, which is acute ; along the posterior dorsal angle of the arm there is a strong, broad membranous fold, with the lower surface strongly concave, white, and crossed by numerous distinct transverse grooves ; the outer edge of the membrane is thin, sharp, white, and curves inward over the groove. The groove with its covering membrane extends close to the tip of the arm, where it terminates in a minute conical papilla ; beyond this, there is a minute, conical, naked tip, but without any appearance of the spoon-shaped cavity and transverse grooves found in other species of *Octopus*.

In alcoholic specimens the entire upper surface is usually very dark purplish brown, varying to dark bluish gray. In some specimens there are obscure patches of darker and lighter over the upper surface. In all the specimens examined there is a large, rounded, purplish black spot near the base of the web, and corresponding to the interval between the second and third pairs of arms. Lower surface of the body, head, and web much lighter than the upper surface, dull grayish or yellowish white, finely specked with purplish chromatophores. Terminal portion of the siphon darker, much like the dorsal surface, inner surface of the web and arms grayish purple, paler than the upper surface. Inner surface and rim of the suckers yellowish white.

The largest male observed (from San Diego, Cal.) has the dorsal arms 325 and 390 mm. long, from the mouth ; second pair of arms, 540 and 450 mm. long ; third pair of arms on left side, 550 mm.; right (hectocotylized) arm, 400 mm. ; ventral arms, 500 and 490 mm.; greatest transverse diameter of the dorsal arms, 20 mm.; lateral arms, 25 mm.; ventral arms, 20 mm.; diameter of the larger suckers of the lateral arms, 11 to 14 mm.; of the twelfth sucker, 15 to 16 mm.; breadth of the web between dorsal arms, from the mouth, 60 mm.; between lateral arms, 70 to 100 mm.; between ventral arms, 60 mm.; length of body, 70 mm.; greatest breadth, 75 mm.; vertical thickness, 42 mm.; breadth of head across eyes, 45 mm.; breadth of dark spot at base of web, 20 mm.

A somewhat smaller male, with the tissues more contracted, has the dorsal arms 265 mm. long ; second pair of arms, 270 mm. (probably reproduced) and 280 mm.; third pair of arms, 300 mm. (left side) ; hectocotylized arm, 265 mm.; ventral arms, 285 mm.; diameter of the twelfth sucker of the lateral arms, 20 to 22 mm.; of the adjacent suckers, 12 to 14 mm.; length of body, 70 mm.; breadth, 60 mm.; breadth of head, 45 mm.

This species has an extensive southern distribution on the Pacific coast. It is common at San Diego, California, where it has been obtained by Dr. Edward Palmer and others. Numerous small specimens were obtained at Panama and on the coast of San Salvador by Mr. Frank H. Bradley, for the Museum of

Yale College, in 1866 and 1867. The largest specimens that I have seen are two males from San Diego, Cal. These were sent to me for description by the National Museum. They were collected by Prof. D. S. Jordan. A female, of somewhat smaller size, from the same locality, was sent to the museum of Yale College by Dr. Edward Palmer.

New Haven, October, 1883.

EXPLANATION OF PLATES.

PLATE IV.

Fig. 1. *Octopus punctatus* Gabb. Male. Dorsal view, from an alcoholic specimen, somewhat restored. Reduced to one fourth natural size.

PLATE V.

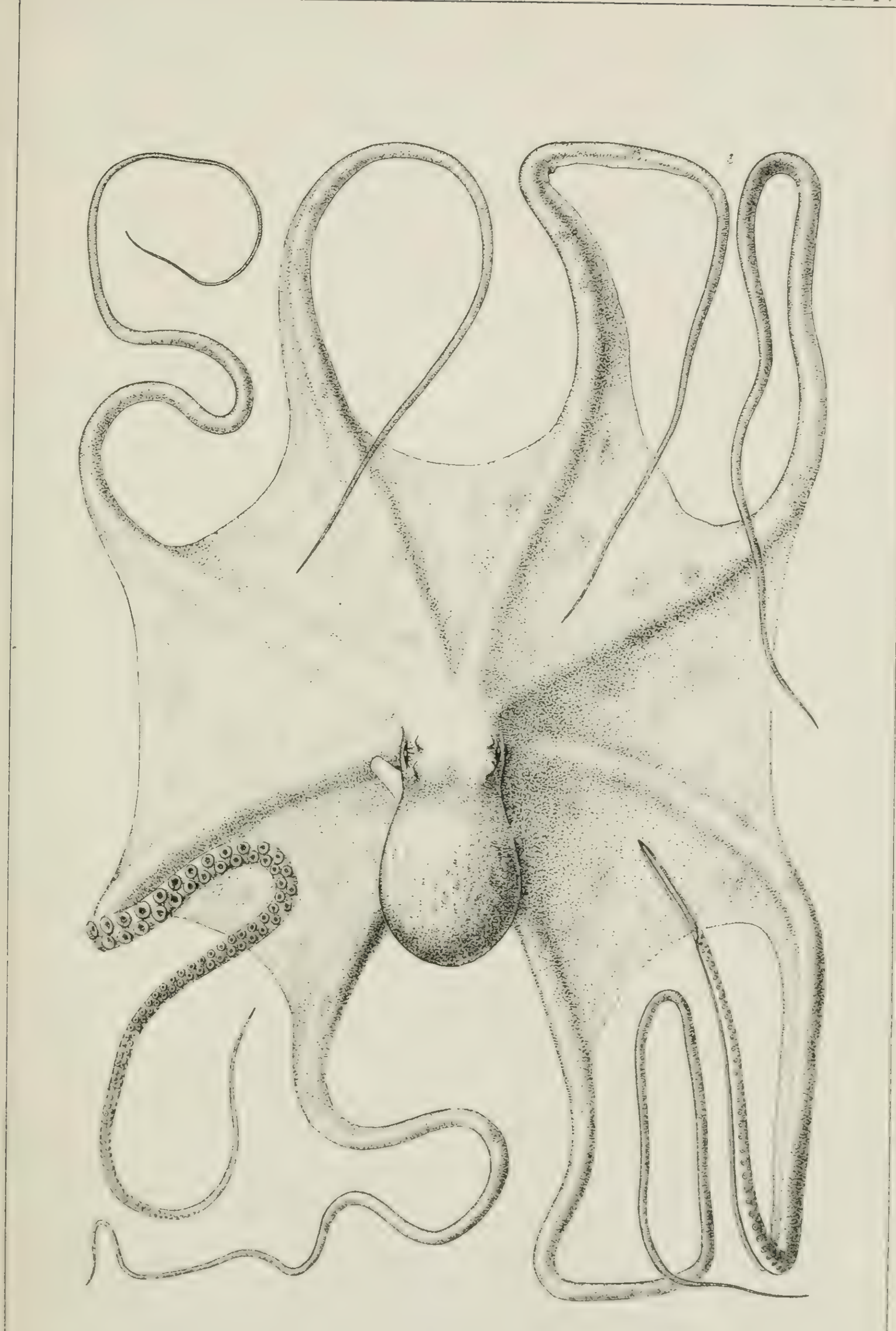
Fig. 1. *Octopus bimaculatus* Verrill. Male. Side view. One half natural size. Somewhat restored from an alcoholic specimen.

" 1 a. The same. Hectocotylized arm. Side view, showing the marginal groove spread open and the very small terminal organ. Enlarged two diameters.

" 2. *Octopus punctatus* Gabb. Distal portion of the hectocotylized arm, front view, showing the terminal organ, spread open, and the commencement of the marginal groove, with a few of the distal suckers. Enlarged two diameters.

PLATE VI.

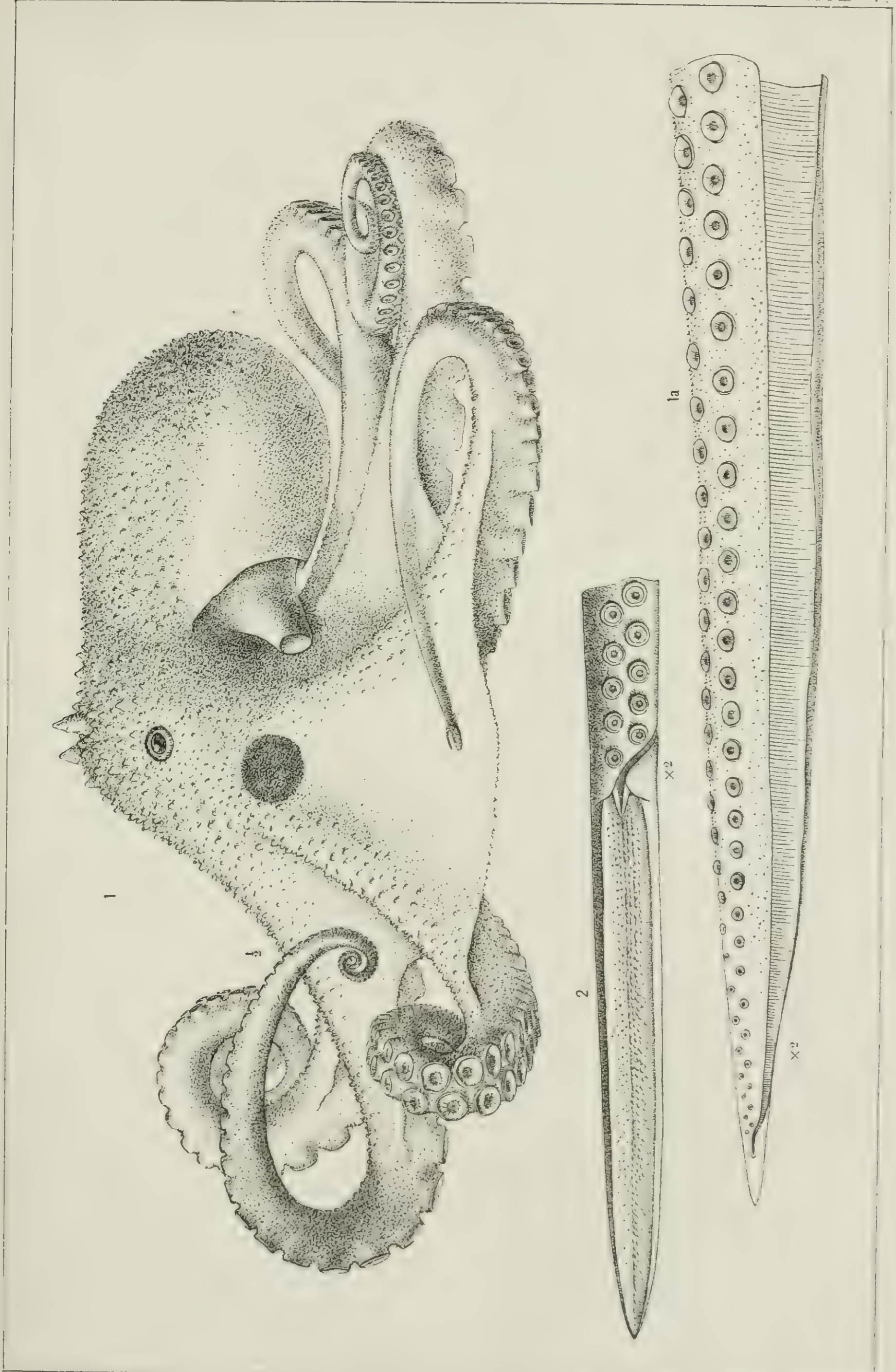
Fig. 1. *Octopus bimaculatus* Verrill. Male. Front view of the inner surface of the web and arms, showing the entire length of the right arm of the second and third pairs, and the basal portion of the other arms. To illustrate particularly the great size of certain suckers of the lateral arms.



J. H. Emerton, from Nature.

Photo. Lith. by L. S. Punderson, New Haven, Conn.

OCTOPUS PUNCTATUS GABB.



J. H. Emerton, from Nature

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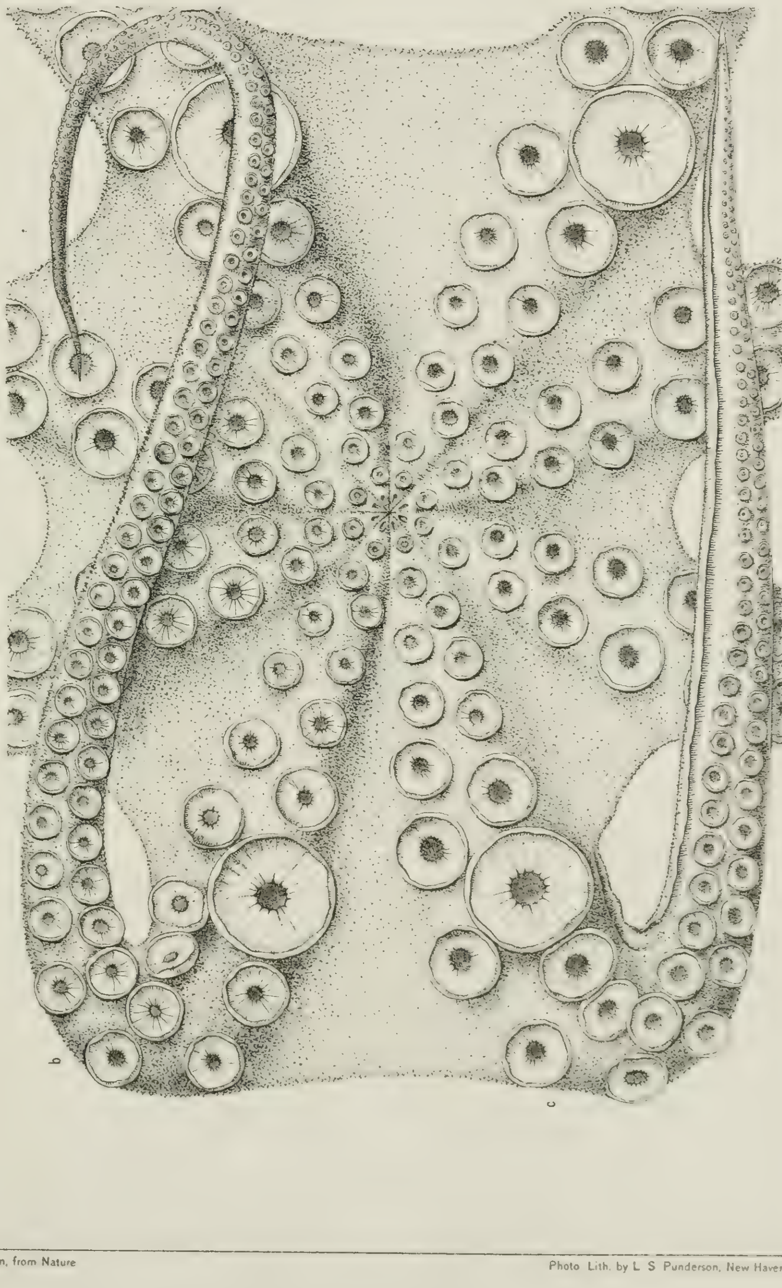
1, OCTOPUS BIMACULATUS 2, OCTOPUS PUNCTATUS



J. H. Emerton, from Nature

Photo Lith. by L. S. Punderson, New Haven, Conn.

OCTOPUS BIMACULATUS VERRILL

No. 7. — *Reports on the Results of Dredging, under the Supervision of* ALEXANDER AGASSIZ, *in the Gulf of Mexico* (1877–78), *and in the Caribbean Sea* (1879–80), *by the United States Coast Survey Steamer "Blake,"* LIEUT.-COM. C. D. SIGSBEE, U. S. N., *and* COMMANDER J. R. BARTLETT, U. S. N., Commanding.

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XXVI.

Verzeichniss der von den United States Coast Survey Steamers "Hassler" und "Blake" von 1867 *zu* 1879 *gesammelten Myzostomiden.* Von Dr. L. v. GRAFF, Professor of Zoölogy at the College of Forestry of Aschaffenburg (Bavaria).

In dem nächsten Bande des "Report on the Scientific Results of the Exploring Voyage of H. M. S. Challenger" wird eine von 16 Tafeln begleitete ausführliche Beschreibung der mir in den letzten Jahren von den verschiedensten Seiten zugekommenen *Myzostomiden* erscheinen. Es befinden sich darunter auch die Formen welche Herr P. Herb. Carpenter (Windsor) von den Crinoideen des "Hassler" und "Blake" ausgesucht und mir mit allen nur wünschenswerthen Notizen übersandt hat. Es sind nicht weniger als 22 Species von denen 21 neu sind. Vierzehn derselben sind dem Blake- und Hassler-Materiale eigenthümlich (ich werde sie in dem folgenden Verzeichniss mit einem * bezeichnen) während der Rest auch in dem von der Challenger-Expedition, und aus den Museen von Copenhagen, Kiel, Bergen, Leiden, etc. stammenden Materiale Repräsentanten hat.

Ohne die allgemeinen Resultate meiner Publication im Challenger-Report zu anticipiren, will ich hier nur eine kurze Beschreibung der von den Schiffen "Blake" und "Hassler" erbeuteten Formen liefern. Dieselben lassen sich folgendermaassen gruppiren: —

AA. Typische Zwitter Myzostomen, meist mit Saugnäpfen versehen, ectoparasitisch lebend und keine Deformitäten an ihren Wirthen erzeugend.

A. Ohne Caudalanhänge.

I. Mit deutlichen Saugnäpfen.

1. Rand der Körperscheibe ohne Cirren, glatt . . **M. longipes.**

2. Rand der Körperscheibe mit Cirren.

a. Jederseits 10 Cirren vorhanden.

α. Cirren sehr kurz, Körper dick und undurchsichtig, meist mit gewölbtem Rücken und ohne hyalinem Randsaum . . . . . **M. areolatum.**
M. marginatum.
M. brevipes.
M. testudo.

β. Cirren lang, Körper meist ein dünnes durchscheinendes Plättchen mit hyalinem Randsaum . . . . **M. pictum.**
M. excisum.
M. crenatum.
M. Agassizii.
M. vastum.

b. Jederseits mehr als 10 Cirren vorhanden.

α. Körper viel länger als breit . . . . . **M. oblongum.**
M. Caribbeanum.

β. Körper kreisförmig, Länge und Breite nicht oder nur wenig verschieden . . **M. irregulare.**
M. elegans.
M. rotundum.
M. abundans.

II. Saugnäpfe fehlen . . . . **M. carinatum.**

B. Mit Caudalanhängen und Saugnäpfen . . . . **M. bicaudatum.**
M. filicauda.

BB. Getrennt-geschlechtliche Myzostomen, ohne Saugnäpfe, Paarweise in Cysten ihrer Wirthe lebend . . **M. cysticolum.**
M. inflator.
M. Murrayi.

* **Myzostoma longipes** n. sp.

Der kreisrunde ockergelbe Körper hat einen Durchmesser von 2 mm. und entbehrt der Cirren sowie eines durchscheinenden Randsaumes. Der Rücken ist mit scharfbegrenzten stumpfen Warzen besetzt. Die Muskulatur ist sehr kräftig und bauchseits tritt dieselbe als gewölbtes Muskelpolster hervor, in dessen Umkreis die grossen bis über den Rand der Körperscheibe ausgestrekten

Parapodien entspringen. Saugnäpfe rund und stark vorspringend. Mund und Cloakenöffnung ventral, subterminal. Ein Exemplar vorhanden.

Host: Incertain. Von Stat. 269 (St. Vincent) der Blake-Exp.†

* **Myzostoma areolatum** n. sp.

Das grössere der vorliegenden Individuen misst in der Länge 1.5 mm. in der Breite 0.9 mm. und stellt eine ovale, undurchsichtige, braune, lederartige Scheibe dar, die am Rande 20 sehr kurze und stumpfe Wärzchen trägt. Der Rücken zerfällt durch Längs- and Querfurchen in vierseitige bis polygonale Felder, die gegen den Rand kleiner werden und ihre longitudinale Anordnung verlieren. Im übrigen ist sowohl Rücken als Bauch flach und letzterer springt etwas vor, so dass eine schmale, dünnere Randparthie sich von der Mittelparthie absetzt, an deren vorderer Grenze ventral der Mund, an der hinteren Grenze die Cloakalöffnung liegen. Die kurzen gedrungenen und breit abgestumpften Parapodien sowie die ovalen Saugnäpfe liegen in der Mittelparthie, der auch allein die Verzweigungen des Darmes und der Geschlechtsorgane angehören.

Host: a. *Actinometra Blakei* P.H.C. von Stat. 172 (Guadeloupe) ; und b. *Act. meridionalis* var. *quadrata* P.H.C. von Stat. 203 (Martinique) und Stat. 278 (Barbados) der Blake-Exp.

* **Myzostoma marginatum** n. sp.

Der kreisförmige Körper des grösseren Individuums hat einen Durchmesser von 2 mm., ist gelbbraun gefärbt, am Rücken gewölbt und mit Warzen von sehr verschiedener Grösse besetzt. Indem die Bauchseite ebenfalls stark vorspringt und sich von dem hier vorhandenen hyalinen Randsaum scharf absetzt, erreicht der Körper eine bedeutende Dicke. Die Randcirren messen bis 0.18 mm. Die Parapodien haben eine mittlere Grösse und stehen im Kreise in der Mitte zwischen Centrum und Rand der Körperscheibe ; etwas mehr nach aussen die kräftigen runden Saugnäpfe. Mund und Cloakenöffnung liegen ventral zwischen Bauchmasse und Randsaum.

Host: Actinometra discoidea P.H.C. von Stat. 155 (Montserrat) der Blake-Exp. Ein anderes Exemplar von Stat. 203 (Martinique) stammt wahrscheinlich von demselben host.

* **Myzostoma brevipes** n. sp.

Das grössere der beiden vorliegende Exemplare hat einen Durchmesser seiner kreisrunden Körperscheibe von 2.3 mm. Die Dicke steht in der Mitte zwischen

† Die Stationsnummern beziehen sich auf die "List of Dredging Stations occupied by the United States Coast Survey Steamers 'Corwin,' 'Bibb,' 'Hassler,' and 'Blake,' from 1867 to 1879," Bull. Mus. Comp. Zoöl., Vol. VI. No. 1, Cambridge, 1879. Die Namen der hosts sind mir von Mr. T. Herb. Carpenter nach seinen Manuscripten mitgetheilt worden, soweit sie zu ermitteln waren.

Myz. glabrum F.S.L., *Myz. cirriferum* F.S.L. Mit letzterem hat die vorliegende Species den Besitz eines hyalinen Randsaumes sowie der 20 kurzen Cirren gemein. Rücken und Bauchhaut glatt, Farbe oben lebhaft Gummigutt-gelb, unten matt graubraun. Saugnäpfe und Parapodien äusserst schwach entwickelt.

Host: Antedon Pourtalesii P.H.C. von Stat. 241 (Cariacou) der Blake-Exp.

* Myzostoma testudo n. sp.

So benannt, weil die mit dichtgedrängten flachen Wärzchen versehene Rückenhaut durch tiefe Längs- und Querfalten in eine Reihe von Mittelfeldern zerfällt, denen sich seitlich fünf Paare von Höckern anschliessen, so dass die Felderung ähnlich wird der des Rückenpanzers einer Schildkröte. Farbe Sepia-braun, Rücken starkgewölbt, Bauch concav mit wenig vorspringendem Muskelpolster. Die schwachen Parapodien sowie die kleinen runden Saugnäpfe stehen viel näher dem Rande als dem Centrum der Bauchscheibe. Die beiden männlichen Genitalpapillen sind grösser als die Parapodien. Mund ventral auf der Höhe der Parapodien-Insertion, Cloakenöffnung desgleichen aber näher dem Hinterrande. Die Randcirren messen bis 0.14 mm. bei einem Gesammtdurchmesser des kreisrunden Körpers von etwas über 4 mm. (bei dem grösseren der beiden Exemplare gemessen).

Host: Actinometra lineata P.H.C. von Stat. 285 (Barbados) der Blake-Exp.

* Myzostoma pictum n. sp.

Durchmesser des einzigen Exemplares 1.8 mm. Gestalt ähnlich dem *Myz. cirriferum* F.S.L., aber derber gebaut als dieses und am Rücken zierlich gezeichnet. Auf hellbrauner Grundlage ein gelblicher Randstreifen, drei ebensolche Längsbänder am Rücken und von diesen zur Seite ausstrahlend eine den Darmverzweigungen entsprechende helle Zeichnung.

Host: Incertain. Von Stat. 157 (Montserrat) der Blake-Exp.

Myzostoma excisum n. sp.

Charakterisirt durch einen Ausschnitt des Hinterendes der dadurch zu Stande kommt, dass die Seitentheile sich über die terminale Cloakalpapille hinaus-erstrecken. Länge in der Medianlinie 0.8 mm., der Seitentheile 1 mm. Farbe des Körpers dunkelbraun. Der Pharynx ist sehr plump und steht weit zum Munde vor. Die runden Saugnäpfe sowie die Parapodien sind massiv und gross.

Host: Antedon Hageni Pourt. gefunden durch das Schiff "Blake," 6 May, 1868, in 96 fathoms, am Alligator-Reef.

Myzostoma crenatum n. sp.

Eine der zierlichsten und regelmässigsten Myzostomen. Der Körper ist völlig kreisrund bei einem Maximaldurchmesser von 1 mm. und die stumpfen Cirren gleichlang und in gleichen Intervallen von einander angebracht. Parapodien schwach, Saugnäpfe oval und sehr gross. Die männlichen Genitalpapillen als Röhren von Parapodiumlänge ausgebildet.

Host: Incertain. Vielleicht *Actinometra meridionalis*, die auf beiden Stationen gefangen wurde, zwischen deren Ausbeute dieses Myzostoma loose gefunden wurde: Stat. 203 (Martinique) der Blake-Exp. und Capt. Cole's Dredging mit dem Amer. Telegraph Steamer "Investigator" bei St. Lucia (13° 22′ N., 61° 7′ W., 278 fathoms).

* Myzostoma Agassizii n. sp.

Von dieser schönen Form die ich zu Ehren des Herrn Al. Agassiz benenne, liegen nicht weniger als 22 Individuen vor. Der Körper ist ausserordentlich dünn und durchscheinend und hat in maximo 1.4 mm. Durchmesser. Die Cirren sind in äusserst feine Spitzen ausgezogen und insoferne von verschiedener Länge, als die beiden letzten Paare viel grösser sind als die übrigen (letztere messen hier durchschnittlich 0.25 mm. während eine der ersteren 0.57 mm. maas). Beine und Saugnäpfe sind sehr schwach und es scheint diese Species im Leben sich hauptsächlich mittelst der Cirren und durch undulirende Schläge mit dem Rand der Körperscheibe lebhaft bewegt zu haben, wie daraus zu schliessen ist, dass die meisten Exemplare den Rand faltig eingeschlagen haben.

Host: a. *Antedon Hageni* Pourt. von Bahia Honda (4 May, 1868, 100 fathoms) und wahrscheinlich auch auf Stat. 32 (1877) der Blake-Exp.

b. Auf Stat. 155 und 269 der Blake-Exp. kommt *Ant. Hageni* nicht vor und es war hier wahrscheinlich *Antedon spinifera* P.H.C. der host.

Myzostoma vastum n. sp.

Die Grösse der Parapodien und Saugnäpfe sowie der Pharynx, namentlich aber die Länge und Dicke der stumpfen Cirren geben dieser Species ein sehr plumpes Ansehen. Von den letzteren sind die ersten beiden und letzten beiden Paare am mächtigsten (bis 0.6 mm. lang und 0.068 mm. breit), die übrigen Cirren erheblich kleiner (ca. 0.2 mm.). Der Körper ist etwas länger als breit (1.7 mm. : 1.47 mm.) und hat einen sehr schmalen Randsaum.

Host: *Actinometra Blakei* P.H.C. von Stat. 39 der Blake-Exp. Dieselbe Actinometra war wahrscheinlich auch der host auf Stat. 23 der Blake-Exp.

* Myzostoma oblongum n. sp.

Das einzige vorliegende Exemplar maas 1.7 mm. Länge, 1 mm. Breite; beide Enden sind abgerundet; der breite, ganz durchsichtige Randsaum trägt 44 fingerförmige Cirren von 0.045–0.18 mm. Länge. Farbe schwach-gelblich.

Host: Wahrscheinlich *Actinometra meridionalis* var. *carinata* P.H.C. von Stat. 249 (Grenada) der Blake-Exp.

* Myzostoma Caribbeanum n. sp.

Eine schmutzig-gelbbraune Scheibe von 1.2 mm. Längs- und 1 mm. Querdurchmesser. Der wenig durchscheinende Rand trägt 43 stumpfe Cirren in allen Grössen abstufungen von unscheinbaren Wärzchen bis zu 0.09 mm. Länge und ohne regelmässige Abwechslung von längeren und kürzeren. Das Hinterende trägt eine unpaare Mediancirre. Parapodien sehr schwach, Saugnäpfe klein und rund.

Host: Incertain. "Blake" 1877–78 or 1878–79, Caribbean Sea (label lost).

Myzostoma irregulare n. sp.

Unter diesem Namen vereinige ich eine Anzahl Myzostomen von wenig über 1 mm. Durchmesser der dünnen mit durchsichtigem Randsaum versehenen Körperscheibe. Sie haben das gemeinsam dass sich ihre Cirren in 20 grössere Hauptcirren und in kleinere (zum Theile warzenförmige) Nebencirren eintheilen lassen, welche letzteren zwischen ersteren zu 1 oder 2 eingepflanzt sind. Doch ergeben sich Unterschiede in der relativen Länge der Cirren sowie in dem Vorhandensein oder Fehlen von unpaaren Mediancirren am Vorder- oder Hinterende oder an beiden zugleich.

Hosts: Actinometra meridionalis A. Ag. sp. und *Act. merid.* var. *carinata* P.H.C. von verschiedenen Stationen der Blake-Exp. (W. of Tortugas, 16 Jan. 1869. — No. 45, 1877–78. — Caribbean Sea, 1877–78 or 1878–79. — Stat. 200, Martinique. — Stat. 249, Grenada.)

Myzostoma elegans Graff.

Ein Exemplar dieser von mir schon früher † beschriebenen Species fand sich auf *Actinometra meridionalis* A. Ag. sp. April 3, 1869, off French Reef, Blake Exped.

* Myzostoma rotundum n. sp.

Ein kreisförmiges dünnes und durchscheinendes Plättchen, am Rande schmutzig-gelb in der Mitte bräunlich gefärbt, von 0.832 mm. Länge und

† "Das Genus Myzostoma," Leipzig, 1877, p. 12, Taf. X. Fig. 1–3.

0.88 mm. Breite. Am Rande zählt man 51 kurze (höchstens 0.08 mm. lange) stumpfe Cirren. Die Parapodien sind schwach, die runden Saugnäpfe gross. Der Darmkanal mit seinem grossen Pharynx ist sehr deutlich zu sehen und entsendet jederseits 5 baumförmig verzweigte Äste.

Host: Wahrscheinlich *Actinometra meridionalis* var. *carinata* P.H.C. von Stat. 249 (Grenada) der Blake-Exp.

* Myzostoma abundans n. sp.

Länge 3 mm., Breite 3.2 mm. Die braune von den kurzen Parapodien umgränzte Mittelparthie ist umgeben von einer gelben Zone in der die Endverzweigungen des Darmes liegen, worauf zu äusserst der ganz helle Randsaum folgt. Dieser trägt an 100 stumpfe Cirren von 0.046–0.14 mm. Länge. Die ovalen Saugnäpfe sind von auffallender Grösse.

Host: Actinometra pulchella Pourt. sp. von Stat. 210 (Martinique) und 224 (St. Vincent) der Blake-Exp. Ein von Stat. 269 stammendes Exemplar war wahrscheinlich auch an der genannten Actinometra-Species angeheftet.

Myzostoma carinatum n. sp.

Das einzige der Saugnäpfe entbehrende Myzostoma unter dem Blake-Materiale. Es ist über 2.5 mm. lang, hellgelb, von der Dicke eines ausgewachsenen *Myz. cirriferum* F.S.L., und wie dieses mit 20 Cirren besetzt. Doch mangelt ein hyaliner Randsaum. Den Rücken ziert eine erhabene Längs-Ciste von der 7 Paar seitlicher Rippen zum Rande abgehen. Die Parapodien sind sehr schwach. Mund und Cloakenöffnung liegen subterminal.

Host: Actinometra pulchella Pourt. sp. von Stat. 193 (Martinique) der Blake-Exp.

* Myzostoma bicaudatum n. sp.

Von Myzostomen mit Caudalanhängen war bisher bloss das von mir beschriebene *Myz. lobatum* † bekannt. Im Challenger-Report werde ich eine ganze Anzahl neuer Myzostomata caudata mit 2, 4 oder 6 Caudalanhängen beschreiben. Es stellen die Caudalanhänge, im Gegensatze zu den Cirren, hohle Aussackungen der Körperscheibe dar, in welche sich die Leibeshöhle mitsammt den Verästelungen des Darmes und der Geschlechtsorgane fortsetzt.

Myz. bicaudatum, wie auch die folgende dem Blake-Materiale entnommene hat bloss 2 Caudalanhänge.

Der fast kreisrunde, dunkelbraune, oben und unten flache Körper ist ohne die Caudalanhänge 0.45 mm. lang und trägt 20 Cirren am Rande. Die drehrunden Caudalanhänge messen von der Basis bis zu ihrem stumpfen Ende 0.3 mm., sie sind bis zur Spitze hohl und enthalten je einen Darmast. Der Pharynx ist sehr gross, Mund und Cloakenöffnung liegen subterminal, ventral, letztere

† *Loc. cit.*, pag. 19, Taf. II. Fig. 3 und 4.

zwischen den Wurzeln der Caudalanhänge. Die runden Saugnäpfe sind klein. die Parapodien schlank und weit abstehend.

Host: Actinomedra meridionalis A. Ag. sp., W. of Tortugas, 16 Jan., 1869, Blake.

* Myzostoma filicauda n. sp.

Ist etwa dreimal so gross als die ebengenannte Species und unterscheidet sich von dieser hauptsächlich durch die Form der Caudalanhänge. Diese zerfallen nähmlich in einen dicken Basaltheil der allein hohl ist und etwa ¼ des ganzen Caudalanhanges ausmacht, und einen von der Spitze des Basaltheiles entspringenden dünnen und soliden Terminalfaden, der länger ist als die Körperscheibe des Thieres.

Host: Antedon Hagenii Pourt. sp., off Sand Key, 17 May, 1867, Blake.

* Myzostoma cysticolum n. sp.

Nachdem schon *Willemoes-Suhm* † auf das Vorkommen von endoparasitischen cysticolen Myzostomen aufmerksam gemacht hatte, war ich in der Lage, an einem reichen Materiale die interessanten Beziehungen dieser Myzostomen zu ihren Wirthen darlegen und namentlich auch die eigenthümlichen Geschlechtsverhältnisse derselben studiren zu können. Indem ich in dieser Beziehung auf meine ausführliche Publication verweise, bemerke ich hier bloss, dass folgende Arten von Deformitäten durch Myzostomen an Crinoideen hervorgerufen werden : —

1. Einfache Verbreitungen der Pinnulæ durch äusserliches Einhacken ;
2. Verbreiterung der Pinnulæ mit gleichzeitiger spiraliger Einrollung derselben, wodurch eine Kammer gebildet wird, in der ein Myzostoma-Paar wohnt ;
3. Birnförmige Auftreibung der Pinnulæ, deren Innerer hohl ist und die Myzostomen beherbergt ;
4. Verschiedene Arten von hohlen Auftreibungen der Arme ; und schliesslich,
5. Selbständige Cysten, d. h. solche, die nicht durch Umbildung der Pinnula- oder Armglieder entstehen, sondern selbstständige durch Kalkablagerung erhärtende Auswüchse der Haut der Ambulacralseite darstellen. Solche Cysten kommen sowohl an den Armen wie an der Scheibe vor und alle drei cysticolen Blake-Myzostomen bilden Cysten dieser Art.

Myz. cisticolum bildet an der Ambulacralseite der Arme von *Actinometra meridionalis* var. *carinata* P.H.C. wurst- oder eiförmige Cysten von ca. 3 mm. Länge und 2 mm. Breite. Jede Cyste hat an einem Ende ein kleines Löchelchen, welches in den Cystenraum führt. Hier findet sich stets ein grosses Weibchen von 2 mm. Durchmesser und ein Zwergmännchen von 0.8 mm. Durchmesser. Der Körper des Weibchens ist ausserordentlich dick und mit

† "Von der Challenger-Expedition," III. Brief, Zeitschrift f. wiss. Zool., Bd. XXV., 1875, pag. xxxi., und VI. Brief, ebendaselbst Bd. XXVI., 1876, pag. lxxix.

seinen Seitentheilen zum Rücken aufgeschlagen. Es fehlen ihm sowohl Saugnäpfe als Parapodien (deren Stelle bloss noch durch rudimentäre, wenig über die Oberfläche vorragende Häckchen vertreten wird). Seine Leibeshöhle ist erfüllt von Eiern und nur ganz spärliche Rudimente von Hoden sind noch vorhanden, die aber, da die männlichen Geschlechtsöffnungen fehlen, nie zur Funktion kommen. Im Männchen, dessen Körper ganz dünn und glatt ist, finden sich bloss die beiden compacten Hoden und keine Spur von weiblichen Geschlechtsöffnungen. Dagegen sind die Parapodien desselben als kleine conische Erhebungen wahrzunehmen. Bei dem Geschlechtern fehlen Cirren und Mund sowie After (resp. beim Weibchen Cloakenöffnung) liegen terminal.

Host: Actinometra meridionalis var. *carinata* P.H.C., von Cape Trio, 22 Jan., 1872, Hassler- und Stat. 249 (Grenada) der Blake-Exp.

Myzostoma inflator n. sp.

Ist durch seine langgestreckte Gestalt und überaus reiche dichtgedrängte Darmverzweigungen ausgezeichnet. Auch ist das Weibchen hier platt und nicht in der Mitte so colossal verdickt wie bei *Myz. cysticolum.* Reste von Hoden wurden bei dem Weibchen dieser und der folgenden Species nicht constatirt. Länge des Weibchens 2.2 mm. bei 1.2 mm. Breite, Länge des Männchen 0.9 mm. bei 0.8 mm. Breite. Cirren, Saugnäpfe und Parapodien wie bei der vorigen Species.

Die Cysten entweder birnförmig und beweglich verbunden mit den Armen (auf *Ant. angustiradia* P.H.C. von der Challenger-Expedition) oder in ganzer Länge mit der Scheibe fest verwachsene Auftreibungen von Wurstförmiger Gestalt und 3 mm. Länge (auf *Actinometra pulchella* Pourt. sp. von Stat. 294 der Blake-Exp.).

Myzostoma Murrayi n. sp.

Diese Species ist sehr ähnlich der vorigen und unterscheidet sich hauptsächlich durch die bedeutendere Grösse (Weibchen bis 5.5 mm. Männchen 1.3 mm.) beider Geschlechter und den kreisförmigen contour namentlich des Weibchens. Die Cysten messen bis 8 mm. Länge, sind sehr schmal und langgestreckt, gegen das freie Ende keulenförmig verdickt während das dünnere Ende die Anheftung an den Armen oder der Scheibe des Wirthes bewerkstelligt.

Host: Antedon duplex P.H.C. von Stat. 269 (St. Vincent) der Blake-Expedition. Die Challenger-Expedition brachte von Stat. 170 und 192 Exemplare des *Antedon radiospina* P.H.C. und *Ant. angustiradia* P.H.C. mit, welche Cysten desselben Myzostoma aufwiesen.

Received, November 7, 1883.

No. 8. — *A Supplement to the Fifth Volume of the Terrestrial Air-Breathing Mollusks of the United States and Adjacent Territories.* By W. G. Binney.

The following pages embody all the additional information relating to the subject which I have been able to obtain since the publication in the Bulletin of the Museum of Comparative Zoölogy, Vol. IV., of the fifth volume of the Terrestrial Air-Breathing Mollusks of the United States.

Burlington, New Jersey, July, 1883.

In the chapter on Geograpical Distribution several additions and corrections are to be made.

On p. 18 to the first list add: —

Onchidium Carpenteri.

The species are said to range over the *whole* of the Pacific Province. Some of them are only coast range species in California, not being found in the Sierra Nevada.

On p. 19 to the second list add: —

Macrocyclis Hemphilli.

Onchidium borealis.

In the Californian Region (p. 19), the range of the species is limited, as shown in the descriptive portion of the work. Most of the species are confined to the vicinity of the coast; as, —

Macrocyclis Voyana.
Duranti.
Limax Hewstoni.
Ariolimax niger.
Hemphilli.
Andersoni.
Aglaia infumata.
Arionta arrosa.
exarata.

Arionta Nickliniana.
Californiensis.
Traski.
Carpenteri.
sequoicola.
Dupetithouarsi.
Diabloensis.
Stearnsiana.
Euparypha Tryoni.

Glyptostoma Newberryanum.
Pupa Rowelli.
Californica.
Onchidium Carpenteri.
Veronicella olivacea.

Still as coast species, but confined to islands, are: —

Arionta intercisa.
Ayersiana.
Kelletti.
Arionta ruficincta.
Gabbi.
Binneya notabilis.

In the Sierra Nevada are found: —

Vitrina Pfeifferi.
Zonites Whitneyi.
chersinellus.
Gonostoma Yatesi.
Polygyra Harfordiana.
Aglaia Hillebrandi.
Arionta Mormonum.

Both in the coast counties and Sierra Nevada are found: —

Ariolimax Californicus.
Triodopsis loricata.
Arionta tudiculata.

The last species near the coast only between San Buenaventura and San Diego.

Pupa corpulenta is incorrectly referred in the lists to the Pacific rather than Central Province.

On p. 21, in the first list add: —

Macrocyclis Hemphilli.

In the second: —

Onchidium Carpenteri.

To the list on p. 22 add: —

Onchidium Carpenteri.
borealis.
Macrocyclis Hemphilli.

And omit *Pupa corpulenta*, a species restricted to the Central Province. This last species is to be added to the list on p. 24.

To the list on p. 33 add: —

Zonites petrophilus.
Wheatleyi.
Rugeli.
Lawi.
cuspidatus.
Zonites macilentus.
Andrewsi.
Patula Bryanti.
Helicodiscus fimbriatus.
Mesodon Andrewsi.

To the list on p. 37 add: —

Triodopsis Levettei.
Triodopsis Copei.

Glandina truncata, Gmelin. (p. 84.)

Found also in North Carolina.

Glandina Texasiana, Pfeiffer. (p. 87.)

Found also in Louisiana.

Macrocylis Voyana, Newcomb. (p. 93.)

A smaller variety of 9 mm. greater diameter is found at Los Angeles.

Macrocylis Hemphilli, W. G. Binn.

Plate II. Fig. M.

At Olympia, Oregon, Mr. H. Hemphill collected several specimens of a *Macrocyclis*, which appears to be distinct from, though nearly allied to, *M. Vancouverensis*. It may be best described by saying that

The umbilicus is narrower and not excavated so much, the termination of the last whorl not receding from the umbilicus as in all the forms of *Vancouverensis* and *concava;* in all, the whorls are more or less strongly striated within the umbilicus, often almost ribbed in *concava;* not so in this shell; the texture of the shell is glassy like *Hyalina*, and there is no trace of the microscopic spiral lines found in all the other forms; beneath, the last whorl is proportionately wider. The greater diameter is 14 mm.; lesser, 10; height, 5.

The jaw and lingual dentition are as usual in the genus. I could not distinguish the characters of the central tooth in this species.

Zonites capnodes, W. G. Binn. (p. 98).

Plate III. Fig. C.

Living specimens received from near Knoxville, Tenn., through the kindness of Mrs. George Andrews, have enabled me to figure the genitalia. The genital bladder (*g. b.*) is large, globular, on a short, narrow duct: the penis-sac (*p. s.*) has the same peculiar accessory process which I have detected in those of *Z. lævigatus*, *Rugeli*, *fuliginosus*, *friabilis*, and *inornatus*. There is a vaginal prepuce.

It is in many individuals more easy to distinguish *capnodes* from *fuliginosus* by the dentition than by the shell.

Zonites fuliginosus, Griff. (p. 100.)

In a specimen from Indiana, sent me by Mr. F. Stein, I find the same accessory process to the penis-sac noticed above. It is not given in Leidy's figure in Vol. I.

Zonites Rugeli W. G. Binn.

Plate II. Figs. H, I. Plate III. Fig. D.

Shell depressed globose, perforated, thin, delicately wrinkled, the apical whorls sometimes striate, greenish horn-colored, dark smoky above; spire slightly elevated, apex flat; whorls 6, slightly rounded, the last globose, scarcely excavated at the perforation; aperture large, rounded, oblique; peristome simple, thin; ends slightly approaching; the columellar one scarcely broadened. Diameter, larger, 19 mm.; lesser, 15 mm.; height, 9 mm.

Zonites Rugeli, W. G. Binn., Ann. N. Y. Acad. Sci., Vol. I. No. 2, p. 357, Pl. XV. Fig. H, Pl. XIV. Fig. D, 1879.

Roan Mountain, Mitchell Co., North Carolina. Mrs. George Andrews.

When first received, I believed this to be an extremely globose form of *Z. inornatus*, but an examination of the lingual dentition showed this to be impossible.

I have given a figure of the genitalia. It will be seen that the accessory part of the penis-sac is in this species continued to a point beyond the retractor-muscle: otherwise the genitalia are very similar to those of *capnodes*, *friabilis*, *inornatus*, *lævigatus*, and *fuliginosus*.

Jaw as usual in the genus. Lingual membrane as usual: teeth 38–1–38. There are about 4 or 5 laterals; the 8th is a pure marginal on either side of the central line. It will be seen that *inornatus*, *subplanus*, and *lævigatus* are peculiar in having no perfect lateral teeth, but only transition teeth: *fuliginosus*, *capnodes*, and *friabilis*, as well as *Rugeli*, have well-formed laterals, differing in number in the various species: thus the lingual dentition in this group is a good guide in distinguishing the species.

The animal is dark slate-colored: the caudal mucus-pore is a longitudinal slit, as in *suppressus*.

Some individuals have their apical whorls striate, as in *Z. subplanus*.

Zonites lævigatus, Pfeiffer. (p. 102.)

The caudal mucus-pore seems to be round, and not a simple longitudinal slit as in *Z. capnodes*, *friabilis*, *fuliginosus*, *Rugeli*, and *inornatus*.

The globose variety shares with the type the peculiar lingual dentition.

Zonites demissus, Binney. (p. 104.)

Found also at Cedar Keys, Florida, and Texasana, Texas.

From the mountains of North Carolina and Tennessee I have received a gradual series of size from the typical *demissus* to *acerrus*.

Zonites intertextus, Binney. (p. 106.)

I have received it from Texas.

Zonites subplanus, Binney. (p. 107.)

Plate II. Fig. J.

This rare species has lately been found on Roan Mountain, Mitchell Co., North Carolina, by Mrs. George Andrews.

The dentition (see plate) is the same as in *Z. inornatus.*

The shell from Roan Mountain is very dark, almost black. Wyoming Co., Pennsylvania (J. S. Phillips).

Zonites sculptilis, Bland. (p. 109.)

Found also at the mouth of Laurel River, Wilby Co., Kentucky (A. G. Wetherby).

Zonites cerinoideus, Anthony. (p. 111.)

Zonites cuspidatus, Lewis, is a variety of *Z. gularis,* or a distinct species. See below, p. 143.

Zonites cellarius, Müller. (p. 111.)

St. Louis (L. B. Case).

Zonites Whitneyi, Newcomb. (pp. 113, 432.)

Plate III. Fig. L.

The dentition is figured on the plate referred to.

Zonites viridulus, Menke. (p. 115.)

Portland, Oregon (H. Hemphill).

Zonites indentatus, Say. (p. 116.)

To the synonymy add : —

Hyalina subrupicola, Dall, Bull. U. S. Geol. and Geogr. Survey of the Territories, Vol. III. No. 1, p. 163, Fig., April, 1877.

A copy of Dr. Dall's description and figure are here given (the latter on Pl. IV. Figs. H, I) : —

Of the following species, described by Mr. W. H. Dall, several examples

occurred. Specimens were sent to Mr. W. G. Binney, who regards it as "apparently an albino variety of *Zonites indentata*." Specimens were submitted to Prof. J. S. Morse, who judged it to be quite distinct from *Z. indentata*. Other specimens were sent to Mr. Dall, who describes it as a new species, and has kindly prepared the following notice.

HYALINA SUBRUPICOLA, n. sp. (Fig. 7).

This little shell is best described by a comparison of its various characteristics with those of *H. indentata*, Say, as given by Mr. Binney in his Land and Fresh-water Shells of the United States (Part I. p. 35).

H. subrupicola, while exhibiting radiating lines of growth, some of which are more conspicuous than others, does not show any such well-marked grooves or indentations as are figured by Morse (Land Shells of Maine) in *indentata*, and which form its most striking character. The former has five and a half whorls, with a greatest diameter in the largest specimen of 0.14 inch, while *indentata* has but little more than four, with a diameter of 0.20 inch. The former is perfectly pellucid, while the latter has a peculiar whitish spermaceti-like lustre. *H. subrupicola* has the last whorl smaller proportionally than *indentata*, and in fact the increment of the whorls in the former is much more regular and even. The umbilicus in both is precisely similar.

The animal of *subrupicola* varies from whitish to slaty ; the granules of the upper surface of the foot are remarkably coarse and well marked. The tentacles are, as contracted in alcohol, hardly perceptible ; the eye-peduncles are from the same cause not extended, but appear to be as usual in the genus, and to possess normal ocular bulbs. The office filled by these, however, being quite as much of a tactile nature as for purposes of sight, the usual rule in regard to the blindness of most cave animals does not apply in the case of the *Helicidæ*. With the exception of *H. indentata*, this species does not seem very near to any of the described American species, and it is totally dissimilar to *Ammonitella Yatesii*, J. G. Cooper, a remarkable form found in caves in Calaveras County, California.

Hab. — Cave in Utah. Collected by Dr. A. S. Packard, Jr., of Dr. Hayden's Survey.

It may be noted that *H. indentata* does not appear to have been collected west of the Rocky Mountains.

Zonites petrophilus, BLAND.

Plate I. Fig. F.

T. late umbilicata, depresso-subglobosa, tenuis, nitens, translucens, albida, irregulariter striata ; sutura mediocris ; anfr. 5½–6, convexiusculi, ultimus convexior, non descendens ; umbilicus extus late excavatus, perspectivus ; apertura rotundato-lunaris ; peristoma simplex, paululo subincrassatum, sæpe roseum, margine columellari reflexiusculo.

Shell broadly umbilicate, depressed ; subglobose, thin, shining, translucent, whitish, irregularly striated ; suture moderately impressed ; whorls 5½–6, rather convex, the last more convex, not descending ; umbilicus widely excavated externally, pervious ; aperture roundly lunate ; peristome simple, somewhat thickened, often rose-colored, the columellar margin slightly reflected. Diameter, greater, 6mm. ; lesser, 5–5¼ mm. ; height, hardly 3 mm.

Zonites petrophilus, Bland, Ann. N. Y. Acad. Sci., Vol. II., Fig., p. 369 (1883).

The Cliffs, Knoxville, Tennessee, found with *Z. Wheatleyi*, Mrs. George Andrews.

This species is, in general form, nearly allied to *Z. arboreus*, but the color is different, the striæ are more developed, and the umbilicus is much wider.

My friend, Mr. W. G. Binney, examined the dentition of *Z. petrophilus*, and favored me with notes on the subject. He found the teeth 15–1–15, with two perfect laterals, one only on each side. *Z. viridulus* has the same number of laterals, but many more marginals.

I would express my deep obligation to Mrs. Andrews for her uniform kindness and liberality in supplying me, during many years, with numerous rare and interesting species. (Bland.)

Fac-similes of the original figures are given on Pl. I. Fig. F.

Zonites Wheatleyi, Bland.

Plate I. Fig. G.

T. umbilicata, depressa, tenuis, nitens, pellucida, fusculo-cornea, delicata striatula; spira subplanulata; sutura leviter impressa ; anfr. 4½, convexiusculi, ultimus basi convexior, ad aperturam rapide accrescens, vix descendens ; umbilicus pervius ; apertura depressa, oblique lunaris ; peristoma simplex, acutum, marginibus approximatis, callo tenui junctis.

Shell umbilicated, depressed, thin, shining, pellucid, brownish horn-colored, finely striated ; spire subplanulate ; suture slightly impressed ; whorls little convex, the last more convex at the base, rapidly increasing at the aperture, scarcely descending ; umbilicus pervious ; aperture depressed, obliquely lunate ; peristome simple, acute, the margins approximating, joined by a thin callus.

Greater diameter, 5 mm. ; lesser, 3½ mm. ; height, 2 mm.

Zonites Wheatleyi, Bland, Ann. N. Y. Acad. Sci., Vol. II. p. 368, Fig. 1 (1883).

The Cliffs, Knoxville, Tennessee, Mrs. George Andrews ; also, Tiverton, Rhode Island, J. H. Thomson.

This, with the following species (*petrophilus*), was discovered and communicated to me, in 1879, by Mrs. Andrews, who thus described the locality in which the two species were found : "The Cliffs rise up 200 feet on the south side of the river ; they are very steep and rocky, face the north, are almost

always shady, damp, and covered with mosses and ferns. I collected the shells on the ledges of the rocks among the dead leaves, at an elevation above the river of about 100 feet. I have not found either of the species in any other locality."

Mr. J. H. Thomson, to whom I submitted specimens, sent to me examples of the same species collected by him, "on a high rocky ledge, covered with old trees, at Tiverton, Rhode Island."

This species, *Z. Wheatleyi*, is more nearly allied to *Z. viridulus*, Menke, than to any other North American form, but differs from it, especially in the form of aperture, in the descending last whorl, and in having a wider umbilicus.

I dedicate the species to the memory of my late valued and lamented friend, Charles M. Wheatley. (Bland.)

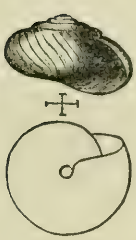
Fac-similes of the original figures are given on Pl. I. Fig. G.

Zonites Binneyanus, Morse. (p. 121.)

Vermont.

Zonites conspectus, Bland. (p. 122.)

Alaska: Salem, Oregon: Merced Co., California (H. Hemphill.)



Zonites chersinellus, Dall. (p. 123.)

Dr. Dall gives the number of whorls $4\frac{1}{2}$–5. A copy of his original figure is here given, as mine is said by him to be incorrect.

Zonites capsella, Gould. (p. 123.)

Lexington, West Virginia; Knoxville, Tennessee (Mrs. George Andrews).

The true *capsella* has 15–1–15 teeth on the lingual membrane, two on each side of the median tooth being true laterals; the fourth is a marginal.

Zonites placentula, Shuttl. (p. 124.)

Plate II. Fig. A.

The description in Vol. V. is a translation of that of Shuttleworth. Fig. 44 in Vol. V. represents *Zonites Lawi* (see below). The true *placentula* is here figured.

Zonites Lawi.

Plate II. Fig. E.

I propose to indicate under the name of *Z. Lawi* the form here figured and formerly considered by me as *Z. placentula*. When the limits of the species in

this puzzling group are better understood, a description of *Z. Lawi* may be given.

Zonites placentula, W. G. Binn. (not of Shuttleworth), Terr. Moll. U. S., V. 124, Fig. 44, not description.

Mountains of Tennessee and North Carolina.

There is a variety in which is a heavy internal callus or plate like teeth within the aperture.

This species furnished the lingual membrane described in Vol. V. as that of *Z. capsella*.

Zonites fulvus, Müll. (p. 125.)

The dentate form sometimes has radiating rows of teeth, as in *multidentatus*.

Zonites Stearnsi, Bland. (p. 130.)

This species from the ribbed form of its jaw must be considered a *Microphysa* (see below).

Zonites cuspidatus, Lewis. (p. 113.)

Plate II. Fig. C.

This form, previously referred by me to a variety of *Z. cerinoideus*, may be considered a distinct species, or a form of *gularis*. It is not a variety of *cerinoideus* (see p. 111). The internal tooth-like processes within the aperture strongly curved one towards the other form almost an arched space. The umbilicus is closed.

Found by Miss Law in Monroe Co., Tennessee; by Mrs. Andrews on Roan Mountain, Mitchell Co., North Carolina.

Zonites macilentus, Shuttl.

Plate II. Fig. B.

Formerly I referred this to *Z. lasmodon*, but having received specimens from near Shuttleworth's original locality, I am convinced of its being distinct. The original description is given in Vol. III. p. 20.

It is found in the mountains of Tennessee and North Carolina.

Zonites lasmodon, Phillips. (p. 131).

The caudal mucus pore is erect, not the simple longitudinal slit as in *Z. suppressus* (see Fig. on p. 128).

Zonites significans, Bland. (p. 132.)

Plate II. Fig. G.

By an unfortunate mistake another shell is figured on p. 132. That now given correctly represents the species.

Roan Mountain, Mitchell Co., North Carolina (Mrs. G. Andrews).

To synonymy add: —

Hyalina significans, Harper, Journ. Cin. Soc. N. H., Oct., 1881, p. 258, Figs. 2, 2 a.

Zonites multidentatus, Binney. (p. 133.)

Plate II. Fig. F.

For comparison with the last-mentioned and following species an enlarged figure is given.

Zonites Andrewsi, W. G. Binn

Plate II. Fig. D.

The specimen figured was received from Mrs. G. Andrews, who collected it on Roan Mountain, Mitchell Co., North Carolina. It has the general appearance of *Z. significans*, *multidentatus*, and *lasmodon*, but differs so decidedly from each that I propose to designate it by the name of its discoverer. A full specific description can be given later. Compared with *Z. lasmodon*, it has fully 8 whorls, is 6½ mm. in diameter, the umbilicus 1 mm. wide, whilst *lasmodon* with 7 whorls, is 7 mm. in diameter, with an umbilicus 2 mm. wide: the Roan Mountain shell has also five parallel lamellæ, while *lasmodon* has only two, or at most three, and does not show the successive rows of lamellæ which are characteristic of *Andrewsi*, radiating from the centre.

From *Z. significans* it differs in its larger size, greater number of whorls, much wider umbilicus, and in the character of its internal denticles, which are long and winding on the wall of the whorl; while in *significans* the denticles are simply erect and conical, with broad base. The same differences distinguish it from *multidentatus*, which is still smaller than *significans*, and has a much narrower umbilicus.

Zonites Andrewsi, W. G. Binn., Ann. N. Y. Acad. Sci., Vol. I. No. 2, p. 358, Pl. XV. Fig. D, 1879.

VITRINIZONITES, W. G. Binn.

Plate III. Fig. A.

Animal heliciform, blunt before, in motion greatly acuminated behind: mantle subcentral, protected by an external shell: two longitudinal furrows

above the margin of the foot, meeting over a round caudal mucus-pore: distinct locomotive disk to foot: external orifice of combined generative organs on right side of body, far behind the eye-peduncles: of respiratory and excretory organs on the right of the mantle under the peristome: jaw smooth, with median projection: lingual membrane as in *Zonites*, central teeth tricuspid, lateral teeth bicuspid, marginals aculeate.

Shell external, Vitrina-like.

The above generic name is proposed for the shell described as *Vitrina latissima* (p. 136), as it combines the characters of *Vitrina* and *Zonites*. The animal differs from *Vitrina* by having simple, not bifid, marginal teeth to the lingual membrane, and by a caudal mucus-pore, with longitudinal furrows above the margin of the foot, and by the want of an appendiculate mantle. From *Zonites* it differs only in the form of the shell, though the caudal mucus-pore seems to be circular, with projecting process when open, rather than a simple longitudinal slit, as in *Zonites suppressus*. There appears no developed appendiculate mantle process.

The genus in my arrangement will follow *Zonites*.

Vitrinizonites latissimus, Lewis. (p. 136.)

Plate I. Fig. H. Plate III. Fig. A, B.

I here add a figure of the animal in motion (Pl. III. Fig. A), not fully extended, drawn by Miss Emma Pringle. The caudal mucus-pore is circular, bordered with a narrow transversely grooved rim; and when closed is covered completely. When open the cover is raised along its longitudinal centre into a sharp carina, leaving posteriorly, when seen from behind, an erect triangular opening. It thus differs from the simple longitudinal slit found in most of the American species of *Zonites*, such as *friabilis, capnodes, fuliginosus, inornatus, demissus, ligerus, suppressus*, the last figured in Vol. V., Fig. 47. *Z. lævigatus*, however, has a nearer approach to the circular pore of *Vitrinizonites*.

The genitalia are figured on Plate III. Fig. B. The ovary is very large (*ov.*) and stout: the genital bladder (*g. b.*) is globular on a short, narrow duct: the penis-sac (*p. s.*) is very long, narrow, cylindrical, receiving the retractor muscle (*r.*) near its basal termination, and merging at its apex into the vas deferens (*v. d.*). The penis-sac has not the accessory process found in *Zonites capnodes, friabilis, lævigatus, inornatus, fuliginosus*, and *Rugeli*.

The species has been found from Carter Co. to Blount Co., Tennessee, on the dividing line between Tennessee and North Carolina.

On Roan Mountain it is usually found under damp moss.

I am indebted to Miss Annie E. Law for the opportunity of examining the specimen figured. She collected it in June, 1879, at the original locality, Bald Mountain, Blount Co., Tennessee, on dividing line with North Carolina. At Washington Co., Tennessee, it was found by Dr. Rugel. Mrs. G. Andrews found it on Roan Mountain, in North Carolina (over 6,000 feet), on the divid-

ing line with Carter Co., Tennessee, and at Thunderhead of Smoky Mountains, North Carolina.

The lingual membrane is broad and not long; the ends are bluntly truncated. There are about 30 rows of 24–1–24 teeth each, arranged as in *Zonites*. There are six laterals, scarcely one perfect, mostly transition teeth, on each side of the central line; the seventh tooth is a marginal; the twelfth tooth is the largest. Plate I. Fig. H, shows all the teeth from the central to the first fully formed marginal, and the two extreme marginals. The dentition is nearest to that of *Zonites lævigatus*.

Limax campestris, Binney. (p. 149.)

An exhaustive paper by E. L. Mark on the Maturation, Fecundation, and Segmentation of this species will be found in Bull. Mus. Comp. Zoöl., Vol. VI. No. 12.

Limax Hewstoni, J. G. Cooper. (p. 150.)

Found by H. Hemphill, from Portland, Oregon, to San Tomas River, Lower California.

Patula solitaria, Say. (p. 156.)

I have seen one specimen from Madison, Indiana, measuring 35 mm. greater diameter.

Patula strigosa, Gould. (p. 157.)

To synonymy add: —

Helix Bruneri, C. F. Ancey, Le Naturaliste, III. p. 468, Sept. 1st, 1881. (Anguispira.)

Diam. maj. 15½ mm.; min. 14 mm.; alt. 7 mm. — Testa sordide alba, pervie lateque umbilicata, utrinque convexa, valde depressa. Spira obtusissima, latissime subconica; anfr. 5, valde convexis; grosse striis incrementi parum regularibus, costisque spiralibus crenulatis, interdum subinterruptis, supra, in anfranctibus primis præsertim, vix distinctis sculpta. Sutura marginata, impressa, subplanulata. Anfr. ult., ad peripheriam carina exserta, non acuta, munitus, costis spiralibus circa 8 subtus intructus. Apertura subemarginato-circularis, obliqua; peristomium simplex, acutum, marginibus callo tenui junctis. Testa colore sordide albo, vittis duabus brunneis ad peripheriam aliquando munita.

Montana (L. Bruner).

Cette espèce, du groupe de *L'Helix* (*Anguispira*) *Cooperi*, W. G. Binney, m'en semble réellement distincte par la carène très sensible, mais nullement aiguë de son dernier tour, les côtes spirales dont elle est pourvue surtout en dessous, par sa forme beaucoup plus déprimée, également convexe en dessus et

en dessous. L'ombilic parait en proportion plus large. *L'Helix Haydeni* Gabb, en diffère par ses côtes spirales mieux marquées, très apparentes des deux côtes, sa carène plus aiguë, et son ombilic moindre. *L'H. Bruneri* présente avec *L'H. Hemphilli*, à peu près les mêmes différences qu'avec *L'H. Cooperi*. Sauf les côtes spirales, cette coquille présente les plus grands rapports de forme avec *L'H.* (*Xerophila*) *filimargo*, de la Crimée. L'ombilic et la carène sont aussi presque identiques. (Ancey.)

Patula perspectiva, Say. (p. 164.)

A carinated form is found in Union Co., Tennessee.

Patula Bryanti, Harper. (p. 165.)

Plate I. Fig. C.

Shell broadly and perspectively umbilicate, discoidal, nearly flat above, and deeply excavated below; whorls 5, gradually increasing, regularly ribbed, outer whorl bicarinate; color light-brown; aperture small, rhomboidal; peristome simple, acute, having its extremities united. Greater width, $6\frac{1}{2}$ mm.; least, $5\frac{1}{2}$ mm.; height, 2 mm.; width of umbilicus, $4\frac{1}{2}$ mm. (Harper.)

Patula Bryanti, Harper, Journ. of Cincinnati Soc. Nat. Hist., Oct., 1881, p. 258, Figs. 1, 1 a.

Found deeply buried under old logs on Roan Mountain, Mitchell Co., North Carolina.

I have given the original description above, and figures of one of the original specimens kindly furnished by Prof. Harper.

It may prove a carinated variety of *perspectiva*, but apparently deserves to be designated by a specific name.

Patula striatella, Anthony. (p. 165.)

Said to be found in Kamtschatka and Northern China, distinct from *pauper*, by Möllendorff. J. B. Moll. Ges., VIII. 35.

Patula asteriscus, Morse. (p. 167.)

Tacoma, Washington Territory.

Microphysa Stearnsi, Bland.

Plate II. Figs. N, O.

Olympia, Washington Territory, and Portland, Oregon. (H. Hemphill.)

As shown above, from an examination of the jaw and lingual dentition, it

appears that this species is not a *Zonites*, as originally described, but rather a *Microphysa*, like *M. Lansingi* and *M. Ingersolli*. With the former it shares the peculiarity of having a ribbed jaw and aculeate marginal teeth to its lingual membrane.

The jaw has over 19 ribs of the same type as those of *M. Lansingi* (see Pl. II. Fig. O). A portion only of the jaw is figured.

The lingual membrane (Pl. II. Fig. N) has four laterals on each side of the central tooth.

Microphysa Ingersolli, Bland. (p. 173.)

Ogden, Utah.

Onchidella Carpenteri, W. G. Binney. (p. 179.)

Body oblong, extremities bluntly rounded: upper surface regularly arched; below, quite near the edge, the border of the mantle is readily distinguished; most of the under surface is occupied by the broad, distinct locomotive disk: the body is uniformly smoke-colored; the four specimens received vary from 5 to 3 mm. in length.

Onchidium Carpenteri, W. G. Binn., Proc. Phila. Ac. N. Sc., 1860, p. 154. Land & Fresh-W. Sh. N. A., Part I. p. 308, Fig. 545 (1869).

Unfortunately omitted from Vol. V. The locality, Cape San Lucas, is doubtful. It is so referred, probably by mistake, in the volume of Land and Fresh-water Shells of North America, quoted above. There is no jaw, which renders still more peculiar the presence of one in *O. borealis;* on this account, I place the genus in *Agnatha* in the catalogue offered with this. The dentition is as in *O. borealis* (see Vol. V.). The upper margin of the base of attachment is still more prolonged in this species.

Helicodiscus fimbriatus, Wetherby. (p. 186.)

Plate I. Fig. D.

Shell light green color, discoidal or planiform, widely umbilicate, consisting of about five whorls, very gradually increasing in size. Aperture lunate, and oblique to the axis of the shell. Peristome subacute, slightly thickened, and darker than the rest of the shell, the outline somewhat sinuous when viewed from the side of the whorl. Suture deeply and regularly impressed. Umbilicus exhibiting all the volutions. Whorls ornamented with from 6 to 8 revolving ridges, terminating in a fringe-like projection of the epidermis, following this arrangement. Two or three of these ridges on the upper side of the body whorl are often of such prominence as to give that portion of the

shell a fluted appearance. In old shells these epidermal fringes are somewhat worn away, leaving the ridges upon which they stood. Greater diameter, 5 mm.; lesser, $4\frac{1}{2}$ mm.; height, $1\frac{1}{2}$ mm.

In some specimens as many as six teeth may be observed, none of which can be seen on the aperture. (Wetherby.)

Helicodiscus fimbriatus, WETHERBY, Journ. Cincinnati Soc. Nat. Hist., IV., Dec., 1881, p. 9.

Ocoee District, Eastern Tennessee.

The figure is drawn from one of Prof. Wetherby's specimens.

Ferussacia subcylindrica, LINN. (p. 187.)

To the synonymy add:—

Cionella (*Zua*) *Morseana*, DOHERTY, Quart. Journ. Conch., I. 342, Pl. IV. Fig. 2 (1878).

Pupa armifera, SAY. (p. 205.)

I am indebted to M. de St. Simon of Toulouse for a knowledge of the lingual dentition. There are 68 rows of 14–1–14 teeth, of which 7 on each side of the median line are laterals.

Pupa contracta, SAY. (p. 207.)

To the synonymy add:—

Pupa Cincinnatiensis, JUDGE, Quart. Journ. Conch., I. 343, Fig. (1878).

FOSSIL SPECIES OF PUPA. (p. 213.)

Add:—

Anthracopupa, WHITFIELD, Amer. Journ. Sc., [3,] 21, 126, cut.

Vertigo ovata, SAY. (p. 219.)

To the synonymy add:—

Zonites Upsoni, CALKINS, Valley Naturalist, St. Louis, Vol. II. No. 4, Dec., 1880, p. 53, Fig. Home and Science Gossip, Rockford, Illinois, March, 1881.

An examination of the lingual membrane alone would prove this to be a *Zonites*. Until then I retain it in *Vertigo*, as identical with or allied to *ovata*. I have, however, on Plate I. Fig. L, given a copy of one of the original figures, leaving out the striæ, which are exaggerated in the original, and here give the original description, from which the species may be recognized, should it prove a *Zonites*.

Shell conic, thin, transparent, shining, amber-colored, umbilicated; whorls 4½, convex, very finely striated; striæ visible only under microscope. Suture distinct, aperture orbicular; peristome simple, acute, its outer termination perpendicular to the body whorl, the columellar termination reflected over the umbilicus. No internal teeth or process. Greater diameter, 1.35 mm.; lesser diameter, 1.20 mm.; length of axis, 1 mm. Locality, Winnebago Co., Illinois.

The animal not having been examined, I am unable to decide the generic character of the species with certainty; but judging from the shell I believe that it is a *Zonites*, and may be placed in the section *Conulus* of W. G. Binney's arrangement (Terr. Moll., Vol. V.). The shell resembles *A. harpa* in outline, but differs in other respects very materially. It is smaller; the texture of the shell is like that of *Conulus fulvus.* The striæ are visible only under the microscope. It is distinctly umbilicated, and the aperture is not oblique. It is no *Vertigo.* This shell, which is unlike any known *Helix*, was first discovered by Mr. Jesse B. Upson, in a damp meadow farm in Rockford, Illinois, beneath some refuse boards.

I have examined a large number of specimens under the microscope, and have made comparisons with many other species, both American and foreign, but have found none like it. There is no probability of its being an importation. The locality and surroundings forbid that.

I may mention that Messrs. Binney and Bland have examined the shell and agree that it is new. Such being the case, it is a matter of congratulation (though a surprise) to be able to add a new species to the American *Helices* from Illinois. I have the pleasure of naming the shell after the first discoverer, Mr. Upson. (Calkins.)

Mr. Upson suggests to me that the shell is the young of *V. ovata*, as it was found in company with mature specimens of that species.

Veronicella olivacea, Stearns. (p. 243.)

"Lobitos is a small creek entering the sea about forty miles south of San Francisco Bay. The ranch and hamlet through which it passes bear the same name." (Stearns.)

Specimens of the original lot found in Nicaragua have kindly been furnished me by Dr. F. W. Putnam. The jaw has over 20 ribs. The lingual membrane is as usual in the genus.

HEMPHILLIA. (p. 246.)

Plate III. Fig. H.

Animal limaciform, blunt before, swollen at centre, and greatly attenuated behind: tentacles simple: mantle subcentral, large, oval, concealing all but a small portion of an internal shell-plate: longitudinal furrows above the

margin of the foot and caudal mucus-pore, over which is a hump-like process: no distinct locomotive disk: external respiratory and anal orifices at the central right margin of the mantle: orifice of combined genital system near the right eye-peduncle.

Shell-plate horny, small, unguiform, longer than wide, with posterior nucleus and concentric lines of growth, exposed in part.

Jaw ribbed.

Lingual membrane with tricuspid central teeth, bicuspid laterals, and quadrate marginals.

Coast of Oregon.

The swollen central portion of the animal seems the first approach to a turbinate mass of viscera, separated from the foot.

This emended generic description is drawn from larger specimens (40 mm. contracted in alcohol) collected at Portland, Oregon, by Mr. H. Hemphill. Found also at Tacoma, Puget Sound, and Olympia, Washington Territory, by the same collector.

Polygyra auriculata, Say. (p. 263.)

Cedar Keys: St. George's Island, Florida.

Polygyra Texasiana, Moricand. (p. 270.)

Fort Gibson, Indian Territory.

Polygyra Dorfeuilliana, Lea. (p. 278.)

Fort Gibson, Cherokee Nation, Indian Territory: Alexandria, Louisana.

Wetherby suggests the specific name of *Sampsoni* for the variety described in Vol. V.

Polygyra pustuloides, Bland. (p. 287.)

Lookout Mountain, Tennessee.

Polygyra leporina, Gould. (p. 288.)

Fort Gibson, Indian Territory.

Polygyra Harfordiana, J. G. Cooper. (p. 309.)

Fig. 203 is said by Dr. Cooper not to represent his species, but rather the Salmon River small form of *Mesodon devia* var. *Mullani*. I have, therefore, here given a figure of Dr. Cooper's original type of *D. Harfordiana* preserved at the Academy of Natural Sciences at Philadelphia. The species from this seems more nearly allied to *Polygyra* than to *Triodopsis*.

It must be remembered that my figure of the dentition (Pl. VIII. Fig. R) and description of jaw were drawn from the Salmon River shell, not the typical shell found only in the Sierra Nevada region at "Big Trees."

Triodopsis vultuosa, Gould. (p. 312.)

Plate III. Fig. J.

There are 12 ribs on the jaw. The lingual membrane has 20–1–20 teeth, 11 laterals on each side of the median line.

For the variety called *Henriettæ*, see below.

Triodopsis Copei, Wetherby.

Plate I. Fig. J.

Shell reddish, somewhat thin, deeply striated by lines of growth, and of medium size. Spire somewhat depressed in some specimens, slightly more elevated in others. Whorls 5, transversely striated with oblique lines of growth, and increasing very gradually and regularly in size; a faint carina appearing at the junction of the upper third and lower two-thirds of the body whorl, from which the latter tapers inwardly to the base of the shell. Sutures regularly and moderately impressed. Peristome subacute, and broadly reflected outward and downward at the lower two-thirds, and bearing on its basal third an acute carina, within which is seen a prominent, vertical, double tooth, of which the outer portion is the larger. A second tooth is carried by the inner margin of the peristome at the centre of the body whorl, the point of which is in close relation to an arcuate tooth carried by the parietal wall of the aperture. Umbilicus wide, exhibiting most of the volutions. Height, 7 mm.; greater diameter, 14 mm. This size is about the average. (Wetherby.)

Helix Copei, Wetherby, Amer. Nat., Mar., 1877, p.

Twenty miles north of Beaumont, Harden Co., Texas.

It is very like a large *vultuosa*, the aperture not produced beyond the teeth as in *Henriettæ*, but there is no trace of the callus connecting the parietal tooth with the angle of the peristome.

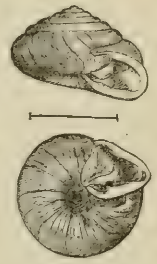
The figure on Plate I. is a fac-simile of that of Prof. Wetherby.

Triodopsis Henriettæ, Mazyck.

Treated as a var. of *T. vultuosa*, p. 313. Perhaps will prove distinct.

Shell rimately umbilicated, depressed, globose, rather solid, with numerous regular delicate striæ, dark brownish horn-color; spire obtuse; whorls about five and a half, slightly convex; suture deeply impressed; beneath convex,

smoother than above ; umbilicus very deep, reaching the apex, but only exhibiting the last three whorls, grooved within ; body whorl gently ascending just behind the aperture, and then suddenly and shortly deflected, very much constricted behind the peristome, with two deep exterior pits, having the space between them elevated into a prominent ridge ; aperture subtriangular, peristome much thickened within and very slightly reflexed, very tortuous, yellowish white, furnished with a small denticle near its upper termination and an erect lamelliform tooth, which is equal in length to about one fifth the diameter of the base of the shell, extending from the lower end of the uppermost pit almost to the inner edge of the body whorl ; low down in the mouth of the shell there is, between this tooth and the denticle, a large white tongue-shaped, concave tooth ; and very near this, but rather lower down in the mouth of the shell, and on the base of the body whorl, there is an oblique stout, white tooth, which is sometimes slightly cleft on the edge. The parietal wall, which is covered with a semi-transparent callus, bears a very strong, arcuated, entering, white tooth, whose outer margins form almost a right angle.



Diameter, major, $\frac{1}{2}$ inch ; minor, $\frac{1}{16}$ inch ; altitude, $\frac{1}{4}$ inch.

Eastern Texas. Mr. Jacob Boll.

This species more nearly resembles *Helix vultuosa*, Gould, than any other North American species, but differs from that shell in the shape and size of the umbilicus and in the form and armature of the aperture, which in *vultuosa* is lunate, almost circular, and in this species is rather V-shaped ; in *vultuosa* the peristome, though moderately so, is decidedly reflexed, and its plane is almost entirely unbroken ; in *Henriettæ* it is very much thickened, but scarcely at all reflexed, is very tortuous, and bears on its inner margin an obtuse denticle and a long lamelliform erect tooth, which are wanting in *vultuosa ;* in *Henriettæ* the two internal teeth are so far within the aperture as to be seen only on looking into it, while in *vultuosa* they are plainly visible from the base of the side ; in the latter the parietal tooth is arched *upwards*, and its outer margin is rounded ; in *Henriettæ* it takes the opposite direction, and its margins form almost a right angle ; the deep pits behind the peristome are wanting or obsolete in *vultuosa*. (Mazyck.) The species is referred to by Mr. Bland in his "Remarks," p. 116.

To the original description of Mazyck I add a figure drawn by Mr. Arthur F. Gray from the original specimen. As stated above, Mr. Bland and myself formerly considered this as a variety of *T. vultuosa*. It seems, however, quite as worthy of specific weight as *T. Copei*.

Triodopsis loricata, Gould. (p. 313.)

Mariposa Co., California.

Triodopsis Levettei, Bland. (p. 314.)

Plate I. Fig. E.

Shell umbilicate, orbiculate-convex, thin, shining, translucent, slightly and irregularly obliquely striated, chestnut-colored, the upper whorls paler; spire scarcely elevated, apex obtuse; suture impressed; whorls 7, rather convex, gradually increasing; the last somewhat depressed at the aperture, obsoletely spirally striated, constricted behind the aperture, and slightly scrobiculated, base subconvex; umbilicus moderate, $\frac{1}{8}$ diameter of the shell, pervious; aperture very oblique, subcircular, with a well-developed flexuose, transverse white tooth on the parietal wall; peristome reflected, pale chestnut-colored, thickened within, the margins joined by a slight callus, the right margin with a white, obtuse, erect, submarginal tooth, the basal margin with two white transverse teeth, the upper one the larger.

Triodopsis Levettei, Bland, Ann. N. Y. Acad. Sci., Vol. II. No. 4, p. 116, Fig. (1880).

Near Santa Fé, New Mexico, where two living and one dead specimen were collected by my friend, Dr. G. M. Levette, who presented to me one of the former. Cabinet of Dr. Levette, and the Binney and Bland collection in the American Museum of Natural History, New York.

This species is quite distinct from any known North American or other form. The number of whorls, and of teeth, their form and color, with the color of the shell and peristome, are its peculiar features. The striæ are by no means so well developed as shown in the figures. (Bland.)

The figures are copied on my plate.

Von Martens suggests that the species may be a *Polygyra*.

Mesodon. (p. 314.)

All the specific names should have the masculine termination.

Mesodon Andrewsi, W. G. Binn. (p. 324.)

Plate II. Fig. L. Plate III. Fig. E, F.

Shell imperforate, globose, very thin, with delicate wrinkles of growth and microscopic revolving striæ; horn-color; spire elevated, conic, apex obtuse; whorls six, convex, the last greatly swollen; peristome white, thickened, slightly reflected, ends separated, the columellar one expanded. Greater diameter, 25 mm.; lesser, 20 mm.; height, 14 mm.

Mesodon Andrewsi, W. G. Binn., Ann. N. Y. Acad. Sci., Vol. I. p. 360, Pl. XIV. Fig. E, F, Pl. XV. (1879).

Roan Mountain, Mitchell Co., North Carolina. Mrs. G. Andrews. The

absence of limestone on Roan Mountain accounts for the extreme thinness of the shell.

It can scarcely be said to resemble closely any known species of *Mesodon*, though perhaps somewhat like a gigantic *M. Mitchellianus.*

The jaw has sixteen ribs.

The lingual membrane (Pl. III. Fig. F) is long and narrow ; teeth 64–1–64, with about 15 perfect laterals on either side of the central line. There are no side cusps or cutting points to the central and lateral teeth, and only on the extreme marginals does a side cutting point appear. The cutting point of the marginals is long. Thus the dentition is like that of *clausus* and *thyroides*.

The genitalia are figured on Plate III. Fig. E. The genital bladder (*g. b.*) is large, oval, on a short, narrow duct : the penis-sac (*p. s.*) is long and stout, with a subcentral constriction : the prostate gland (*pr.*) is highly developed.

A dentate form is figured on Plate IV. Fig. A.

Mesodon Wheatleyi, Bland. (p. 327.)

Roan Mountain, Mitchell Co., North Carolina ; Cliff Springs, Monroe Co., Tennessee. Mrs. G. Andrews. The parietal tooth was wanting in these specimens.

Mesodon dentiferus, Binney. (p. 328.)

Plate III. Fig. G.

On Plate III. Fig. G, I have figured the genitalia of this species.

The genital bladder (*g. b.*) is small, oval, on a short duct, which is greatly swollen at a short distance below the bladder : the penis-sac (*p. s.*) is long, stout, and contracted at a short distance below its blunt end ; the retractor is inserted in the vas deferens at about the middle of its length.

In another individual, the constriction of the penis-sac was not so well developed.

Mrs. G. Andrews found at Sugar-Loaf Mountain, North Carolina, twenty miles east of Roan Mountain, a specimen of 5½ whorls ; greater diameter, 30 mm. ; lesser, 25 mm. ; height, 12 mm.

Mesodon Wetherbyi, Bland. (p. 330.)

Roan Mountain, Mitchell Co., North Carolina ; Campbell Co., Tennessee, Mrs. G. Andrews. Animal uniform slate-color.

Mesodon clausus, Say. (p. 332.)

Helix Ingallsiana. See Fischer, in Shuttleworth's Notitiæ Mal., II. 10, Pl. III. Fig. 5 (1877).

Mesodon Lawi, Lewis. (p. 335.)

Monroe Co., East Tennessee. Mrs. G. Andrews. Houston Co., Georgia.

Mesodon devius, Gould. (pp. 337, 432.)

Plate III. Fig. I.

The genitalia are here figured.

The typical form was found by Mr. H. Hemphill, at Freeport, Cowlitz Co., Washington Territory.

Mesodon Sayii, Binney. (p 339.)

Plate I. Fig. A, B. Plate II. Fig. K.

An opportunity of examining the animal of this large form of *M. Sayii*, for which I am indebted to Dr. Lewis, shows that the genital system (Pl. I. Fig. B) is similar to that of the typical form, excepting that the penis-sac is still more developed, surpassing by three times the whole genital system in length. (See Vol. I., Pl. XI. Fig. 11.)

The jaw and lingual dentition are the same as in the typical *Sayii*. I have figured on Plate I. Fig. A, the dentition of this variety.

In the mountains of Tennessee and North Carolina is found the form called *var. Chiloweensis*, one of which is figured in the plate referred to (Pl. I. Fig. K).

Aglaia fidelis, Gray. (p. 350.)

The small form from Mount Shasta, mentioned on p. 351, which also is found at the Dalles, has the same dentition and genitalia as the typical form. (See Pl. IV. Fig. G.)

There is a black variety from northern parts of California still more nearly allied to *infumata*.

Aglaia infumata, Gould. (p. 352.)

The animal is black with brick-red tubercles. Latitude 37° 30′ is said to be its southern limit. Its shell is sometimes banded. Plate IV. Fig. B, C, represent the species denuded of its hairs.

Aglaia Hillebrandi, Newcomb. (p. 352.)

Calaveras Co., California.

Arionta. (p. 353.)

The species are not well grouped in the text. The following is more natural: —

Arionta arrosa.
Townsendiana.
exarata.
*
Californiensis (including *reticulata Nickliniana, ramentosa, Bridgesi*)
*
intercisa (including *redimita*).
*
Ayersiana.
*
tudiculata.
*

Arionta Mormonum Traski.
Carpenteri.
sequoicola.
Diabloensis.
*
Dupetithouarsi.
*
ruficincta.
Gabbi.
*
Kelletti.
Stearnsiana.

The geographical distribution of the species is very peculiar. *A. Townsendiana* belongs to the Oregon fauna. I doubt its ever having been found in Tuolumne Co., California. *A. Mormonum* belongs to the Sierra Nevada counties, as does *A. tudiculata*, which also is found in southern coast counties. All the others are restricted to the coast counties, ranging as stated in the text, the following being island species: *A. ruficincta, Gabbi, intercisa, Ayersiana*, and *Kelletti. A. Stearnsiana* and *Carpenteri* are Lower Californian species.

The lingual dentition of all the species is essentially the same, excepting *Townsendiana* and *ruficincta*, which have tricuspid centrals and inner laterals. The genitalia are the same in *arrosa, exarata, Nickliniana, Californiensis, Ayersiana, tudiculata, Traski, Carpenteri, sequoicola, Diabloensis*, and *Dupetithouarsi*. From these the genitalia of *Mormonum* differ very essentially, being more nearly allied to that of *Aglaia fidelis* and *infumata. A. Townsendiana* has simple genitalia, without the accessory organs usually found in *Arionta. A. Kelletti* and *Stearnsiana* have the organs still more complicated with accessories. *A. ruficincta* and *Gabbi* are related by their genitalia to the last, but differ considerably in wanting the accessory duct of genital bladder.

I have not examined the genitalia of *intercisa.*

Arionta arrosa, Gould. (p. 354.)

J. G. Cooper, in Proc. Cal. Ac. N. S., 1875, p. 16, indicates a variety, *Holderiana*, and another variety, *Stiversiana.*

Arionta Townsendiana, Lea. (p. 355.)

The variety *ptychophora* is sometimes very thin and smooth, not malleated. I have it from Salmon River, Idaho; Bitter Root Mountains; Dalles, Oregon; Umatilla Co., Oregon. (Hemphill.) (See Pl. IV. Fig. E, F.)

Arionta tudiculata, Binney. (p. 357.)

In the Sierra Nevada from San Diego it ranges 450 miles north. J. G. Cooper says this and *A. Mormonum* are the only large species found east of the coast range.

Dr. Cooper mentions a variety, *Franki*, in Amer. Journ. Conch., V. 209. In letters to me, however, he says this is a misprint for *Traski*.

Arionta Ayersiana, Newcomb. (p. 359.)

San Clemente Island. (Yates.)

Arionta intercisa, W. G. Binney. (p. 360.)

Plate I. Fig. I.

Mr. Henry Hemphill has lately sent me alcoholic specimens, collected by him at San Clemente Island, California.

The jaw is as usual in the genus, with six separated ribs.

The lingual membrane is as usual in the genus. Teeth 31–1–31, with about 15 laterals on each side. The extreme laterals only are bicuspid. (Pl. I. Fig. I.)

The genitalia are like those figured by me for *Euparypha Tryoni*. (See Terr. Moll., V.)

From the series of specimens sent by Mr. Hemphill, I am inclined to believe *Arionta redimita* to be a variety of *intercisa*. The original specimen may have come from the same locality. Formerly I suspected *redimita* to be a variety of *ramentosa*.

Arionta Mormonum, Pfeiffer. (p. 366.)

Pl. I. Fig. K.

The small form from Dalles, Oregon, is probably a small variety of *Aglaia fidelis*. Sonora, Mexico, is given as a locality of this species, from confounding the *town* Sonora of Tuolumne Co., California, with the Mexican *state*. Mormon Island is a rocky islet in the American River, seventy miles north-northwest of this town of Sonora.

A variety is indicated as *circumcarinata* by Stearns (Ann. N. Y. Acad. Sci., Vol. I. p.   , Fig., 1879). A copy of two of his figures is given on Plate I. Fig. K. It is thus described by him : —

Shell widely umbilicated, discoidal, flattened, angulated, with a peripheral keel; whorls six to six and a half, slightly tabulated near the sutures, which latter are deeply impressed; surface finely granulated, varying in different specimens; and otherwise sculptured by conspicuous subacute ribs parallel with the lines of growth both above and below, which meet, and sometimes cross, the peripheral keel; these ribs are more or less irregular and uneven, of varying prominence, and are also unequally spaced, being closely crowded in some places and farther apart in others. Aperture obliquely subangulate, semilunate; peristome moderately thickened, reflected somewhat, covering the open umbilicus, and made continuous by a connecting thin deposit of callus on the labium. Color, in some specimens, dingy white to white, in others a dingy reddish white, ornamented with a double revolving band, — the upper stripe being whitish, the lower reddish or light chestnut just above, and contiguous to the peripheral keel; the pinch or fold of the keel taking up what in *Helix Mormonum* is the third or lower stripe of white.

Number of specimens four, two adult and two immature, but nearly full grown.

Greater diameter, .92 to 1.01 inches; lesser diameter, .75 to .86 inch; height, .36 to .37 inch.

Animal not observed.

Stanislaus County, near Turloch, California. (Stearns).

The form to me appears a distinct species.

Arionta Diabloensis, J. G. Cooper. (p. 369.)

The species ranges one hundred miles north of Mt. Diablo. (Cooper.)

Arionta Traski, Newcomb. (p. 369.)

Dr. Cooper gives its ranges from Los Angeles fifty miles to Fort Tejon, and one hundred and fifty miles to San Luis Obispo. He says the first four whorls are hirsute.

Arionta Dupetithouarsi, Desh. (p. 370.)

In the grove at Cypress Point, Monterey.

Glyptostoma Newberryanum. (p. 374.)

The under surface of a large specimen is figured on Plate IV. Fig. D.

Macroceramus Kieneri, Pfeiffer. (p. 385.)

Mr. Bland (Ann. N. Y. Acad. Sci., Vol. II. p. 127) has shown the United States specimens to be distinct under the name of *pontificus*, Gould.

Bulimulus Schiedeanus, Pfeiffer. (p. 391.)

Plate III. Fig. K.

Jaw slightly arcuate, ends scarcely attenuated, blunt; anterior surface with 17 ribs, denticulating either margin. It is difficult to decide the exact character of these ribs. I have usually called the ribs in *Bulimulus*, *Cylindrella*, etc. narrow and widely separated. They should perhaps be described as very broad, with narrow interstices, and with a gradual increase of thickness towards their outer longitudinal margin. This plainly thickened margin is what I have formerly described as narrow ribs. In the jaw before me there is no tendency to oblique arrangement of the ribs at the upper central portion.

The lingual membrane (see plate) is long and narrow. Teeth of the same type as described by me under *Bul. dealbatus*, Say, in Vol. V.

Bulimulus multilineatus, Say. (p. 395.)

Mexico (Fischer and Crosse).

Orthalicus undatus, Brug. (p. 408.)

The upper figure of Plate LIV. is referred by Von Martens to *O. Ferussaci.*

Succinea ovalis, Gould. (p. 417.)

To the synonymy add: —

S. Calumetensis, Calkins, Valley Naturalist, Vol. I. No. 2, p. 1, with a figure. St. Louis.

Spurious Species of Helicidæ. (p. 431.)

Clausilia acrolepia, "L'Amérique Russe" is a typographical error for "L'Arménie Russe." Zoöl. Rec., 1881.

In the following list I have incorporated all the foregoing additions and alterations.

CATALOGUE

OF THE

TERRESTRIAL AIR-BREATHING MOLLUSKS

OF THE UNITED STATES AND ADJACENT TERRITORIES OF NORTH AMERICA.

PULMONATA GEOPHILA.

Agnatha.

Glandina Vanuxemensis, Lea.
truncata, Gmel.
decussata, Desh.
Glandina bullata, Gld.
Texasiana, Pfr.

Holognatha Vitrinea.

Macrocyclis Vancouverensis, Lea.
sportella, Gld.
concava, Say.
Hemphilli, W. G. Binn.
Voyana, Newc.
Duranti, Newc.
Zonites *Mesomphix.*
capnodes, W. G. Binn.
fuliginosus, Griff.
friabilis, W. G. Binn.
Rugeli, W. G. Binn.
caducus, Pfr.
lævigatus, Pfr.
demissus, Binn.
ligerus, Say.
intertextus, Binn.
subplanus, Binn.
inornatus, Say.
sculptilis, Bland.
Elliotti, Redf.
cerinoideus, Anth.
Hyalina.
cellarius, Müll.
Whitneyi, Newc.
nitidus, Müll.
arboreus, Say.
Zonites viridulus, Mke.
indentatus, Say.
petrophilus, Bland.
Wheatleyi, Bland.
limatulus, Ward.
minusculus, Binn.
milium, Morse.
Binneyanus, Morse.
ferreus, Morse.
conspectus, Bland.
exiguus, Stimpson.
chersinellus, Dall.
capsella, Gld.
placentula, Shuttl.
Lawi, W. G. Binn.
Conulus.
fulvus, Drap.
Fabricii, Beck.
Gundlachi, Pfr.
Gastrodonta.
gularis, Say.
cuspidatus, Lewis.
suppressus, Say.
lasmodon, Phillips.
macilentus, Shuttl.
significans, Bland.

Zonites Andrewsi, W. G. Binn.
internus, Say.
multidentatus, Binn.
Vitrinozonites latissimus, Lewis.
Vitrina limpida, Gould.
Angelicæ, Beck.
Pfeifferi, Newc.
Vitrina exilis, Morelet.
Limax maximus, L.
flavus, L.
agrestis, L.
campestris, Binn.
Hewstoni, J. G. Cooper.
montanus, Ingersoll.

Holognatha Helicea.

Patula solitaria, Say.
strigosa, Gld.
Hemphilli, Newc.
Idahoensis, Newc.
alternata, Say.
Cumberlandiana, Lea.
perspectiva, Say.
Bryanti, Harper.
striatella, Anth.
pauper, Gld.
Horni, Gabb.
asteriscus, Morse.
Microphysa incrustata, Poey.
vortex, Pfr.
Lansingi, Bland.
Ingersolli, Bland.
Stearnsi, Bland.
Hemitrochus varians, Mke.
Holospira Roemeri, Pfr.
Goldfussi, Mke.
Onchidella borealis, Dall.
Carpenteri, W. G. Binn.
Tebennophorus Caroliniensis, Bosc.
Helicodiscus lineatus, Say.
fimbriatus, Weth.
Ferussacia subcylindrica, L.
Cæcilianella acicula, Müll.
Stenogyra *Rumina.*
decollata, L.
Opeas.
octonoides, C. B. Ad.
subula, Pfr.
Melaniella.
gracillima, Pfr.
Pupa *Pupilla.*
muscorum, L.
Blandi, Morse.
Hoppii, Möll.
variolosa, Gld.
pentodon, Say.
decora, Gld.
corpulenta, Morse.
Rowelli, Newc.
Californica, Rowell.
Leucochila.
fallax, Say.
modica, Gld.
Arizonensis, Gabb.
hordeacea, Gabb.
armifera, Say.
contracta, Say.
rupicola, Say.
corticaria, Say.
pellucida, Pfr.
borealis, Morelet.
alticola, Ingersoll.
Vertigo Gouldi, Binn.
Bollesiana, Morse.
milium, Gld.
ovata, Say.
ventricosa, Morse.
simplex, Gld.
Strophia incana, Binn.
* *
Arion fuscus, Müll.
foliolatus, Gld.
Ariolimax Columbianus, Gld.
Californicus, J. G. Coop.

Ariolimax niger, J. G. Coop.
Hemphilli, W. G. Binn.
Andersoni, J. G. Coop.
Prophysaon Hemphilli, Bland & Binn.
Veronicella Floridana, Binn.
olivacea, Stearns.
Binneya notabilis, J. G. Coop.
Hemphillia glandulosa, Bland & Binn.
Pallifera dorsalis, Binn.
Wetherbyi, W. G. Binn.
Strobila labyrinthica, Say.
Hubbardi, A. D. Brown.
Gonostoma Yatesi, J. G. Coop.
Polygyra auriculata, Say.
uvulifera, Shuttl.
auriformis, Bland.
Postelliana, Bland.
espiloca, Ravenel.
avara, Say.
ventrosula, Pfr.
Hindsi, Pfr.
Texasiana, Moricand.
triodontoides, Bland.
Mooreana, W. G. Binn.
hippocrepis, Pfr.
fastigans, L. W. Say.
Jacksoni, Bland.
Troostiana, Lea.
Hazardi, Bland.
oppilata, Moricand.
Dorfeuilliana, Lea.
Ariadnæ, Pfr.
septemvolva, Say.
cereolus, Muhlf.
Carpenteriana, Bland.
Febigeri, Bland.
pustula, Fer.
pustuloides, Bland.
leporina, Gld.
Harfordiana, J. G. Coop.
Polygyrella polygyrella, Bland & J. G. Coop.
Stenotrema spinosum, Lea.
labrosum, Bland.
Edgarianum, Lea.
Stenotrema Edvardsi, Bland.
barbigerum, Redfield.
stenotremum, Fer.
hirsutum, Say.
maxillatum, Gld.
monodon, Rack.
germanum, Gld.
Triodopsis palliata, Say.
obstricta, Say.
appressa, Say.
inflecta, Say.
Rugeli, Shuttl.
tridentata, Say.
fallax, Say.
introferens, Bland.
Hopetonensis, Shuttl.
Van Nostrandi, Bland.
vultuosa, Gld.
Copei, Weth.
loricata, Gld.
Levettei, Bld.
Mesodon major, Binn.
albolabris, Say.
divestus, Gld.
multilineatus, Say.
Pennsylvanicus, Green.
Mitchellianus, Lea.
elevatus, Say.
Clarki, Lea.
Christyi, Bland.
exoletus, Binn.
Wheatleyi, Bland.
dentiferus, Binn.
Roëmeri, Pfr.
Wetherbyi, Bland.
thyroides, Say.
Andrewsi, W. G. Binn.
clausus, Say.
Columbianus, Lea.
Downieanus, Bland.
Lawi, Lewis.
jejunus, Say.
Mobilianus, Lea.
devius, Gld.
profundus, Say.

Mesodon Sayii, Binn.
Acanthinula harpa, Say.
Vallonia pulchella, Müll.
Fruticicola hispida, L.
rufescens, Penn.
Dorcasia Berlandieriana, Moric.
griseola, Pfr.
Turricula terrestris, Chemn.
Aglaia fidelis, Gray.
infumata, Gld.
Hillebrandi, Newc.
Arionta arrosa, Gld.
Townsendiana, Lea.
var. *ptychophora*, A. D. Brown.
exarata, Pfr.
Californiensis, Lea.
intercisa, W. G. Binn.
Ayresiana, Newc.
tudiculata, Binn.
Mormonum, Pfr.
var. *circumcarinata*.
Traski, Newc.
Carpenteri, Newc.
sequoicola, J. G. Coop.
Arionta Diabloensis, J. G. Coop.
Dupetithouarsi, Desh.
ruficincta, Newc.
Gabbi, Newc.
Kelletti, Fbs.
Stearnsiana, Gabb.
Glyptostoma Newberryanum, W. G. B.
Euparypha Tryoni, Newc.
Tachea hortensis, Müll.
Pomatia aspersa, Müll.

* *

Cylindrella Poeyana, D'Orb.
jejuna, Gld.
Macroceramus pontificus, Gld.
Gossei, Pfr.
Bulimulus patriarcha, W. G. Binn.
alternatus, Say.
Schiedeanus, Pfr.
dealbatus, Say.
serperastrus, Say.
multilineatus, Say.
Dormani, W. G. Binn.
Marielinus, Poey.
Floridanus, Pfr.

Goniognatha.

Liguus fasciatus, Müll.
Orthalicus undatus, Brug.
Punctum pygmæum, Dr.

Elasmognatha.

Succinea Haydeni, W. G. Binn.
retusa, Lea.
Sillimani, Bland.
ovalis, Gld., not Say.
Higginsi, Bland.
Concordialis, Gld.
luteola, Gld.
lineata, W. G. Binn.
avara, Say.
Stretchiana, Bland.
Verrilli, Bland.
aurea, Lea.
Groenlandica, Beck.
obliqua, Say.
Succinea Totteniana, Lea.
campestris, Say.
Hawkinsi, Baird.
rusticana, Gld.
Nuttalliana, Lea.
Oregonensis, Lea.
effusa, Shuttl.
Salleana, Pfr.

* *

Haleana, Lea.
Mooresiana, Lea.
Grosvenori, Lea.
Wilsoni, Lea.

EXPLANATION OF THE PLATES.

The figures of shells were drawn by Mr. Arthur F. Gray; those of genitalia and lingual dentition, by W. G. Binney.

PLATE I.

Fig. A. Mesodon Chiloweensis: lingual dentition.
" B. " " genitalia.
" C. Patula Bryanti.
" D. Helicodiscus fimbriatus.
" E. Triodopsis Levettei.
" F. Zonites petrophilus.
" G. " Wheatleyi.
" H. Vitrinozonites latissimus: lingual dentition.
" I. Arionta intercisa: lingual dentition.
" J. Triodopsis Copei.
" K. Arionta Mormonum, *var.* circumcarinata.
" L. Zonites Upsoni.

PLATE II.

Fig. A. Zonites placentula.
" B. " macilentus.
" C. " cuspidatus.
" D. " Andrewsi.
" E. " Lawi.
" F. " multidentatus.
" G. " significans.
" H. " Rugeli: shell.
" I. " " dentition.
" J. " subplanus: dentition.
" K. Mesodon Chiloweensis.
" L. " Andrewsi.
" M. Macrocyclis Hemphilli.
" N. Microphysa Stearnsi: dentition.
" O. " " jaw.

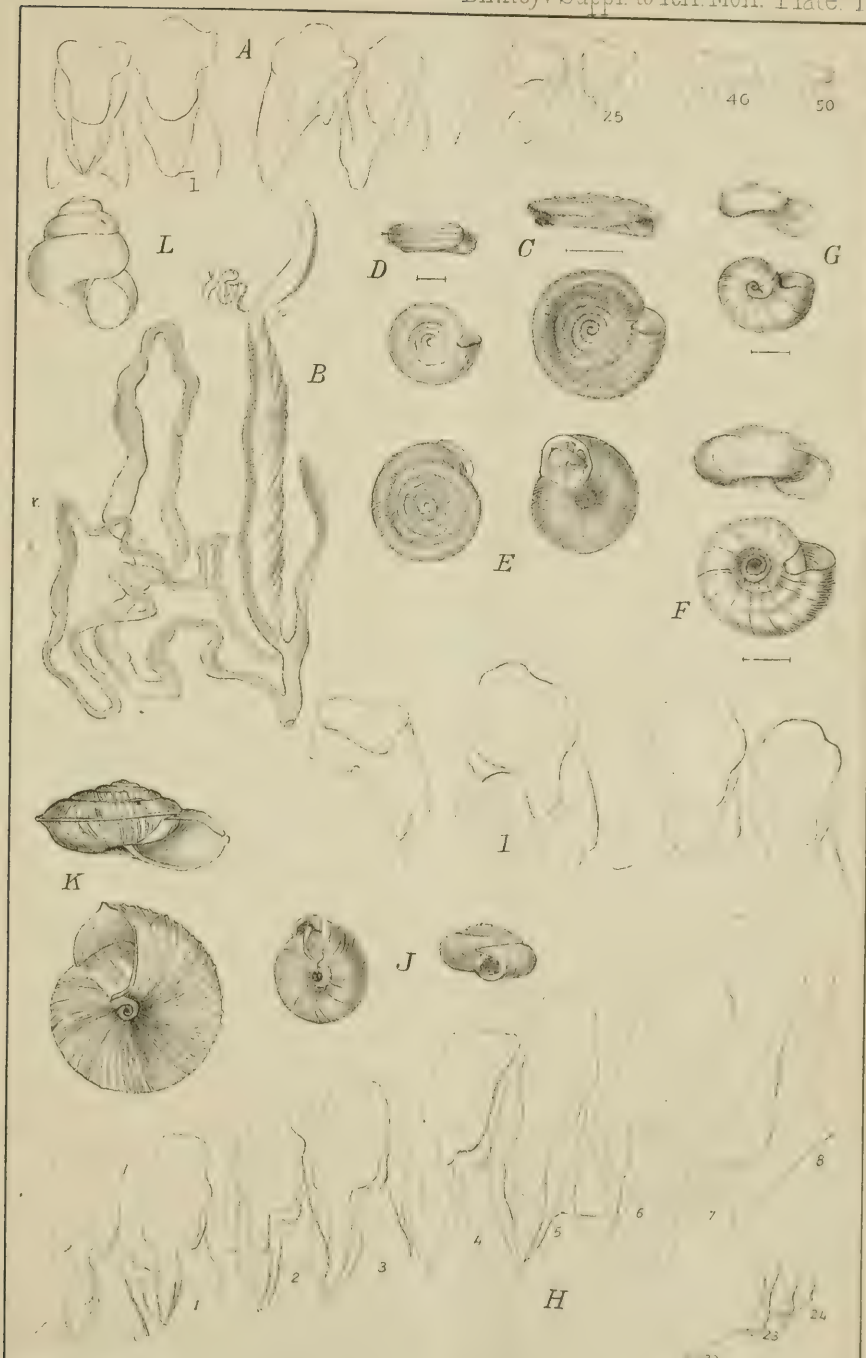
PLATE III.

Fig. A. Animal of Vitrinozonites latissimus : drawn by Miss Emma Pringle.
" B. Genitalia of same.
" C. " Zonites capnodes.
" D. " " Rugeli.
" E. " Mesodon Andrewsi.
" F. Dentition of " "
" G. Genitalia of Mesodon dentiferus.
" H. Animal of Hemphillia contracted in spirits.
" I. Genitalia of Mesodon devius.
" J. Dentition of Triodopsis vultuosa.
" K. " Bulimulus Schiedeanus.
" L. " Zonites Whitneyi.

PLATE IV.

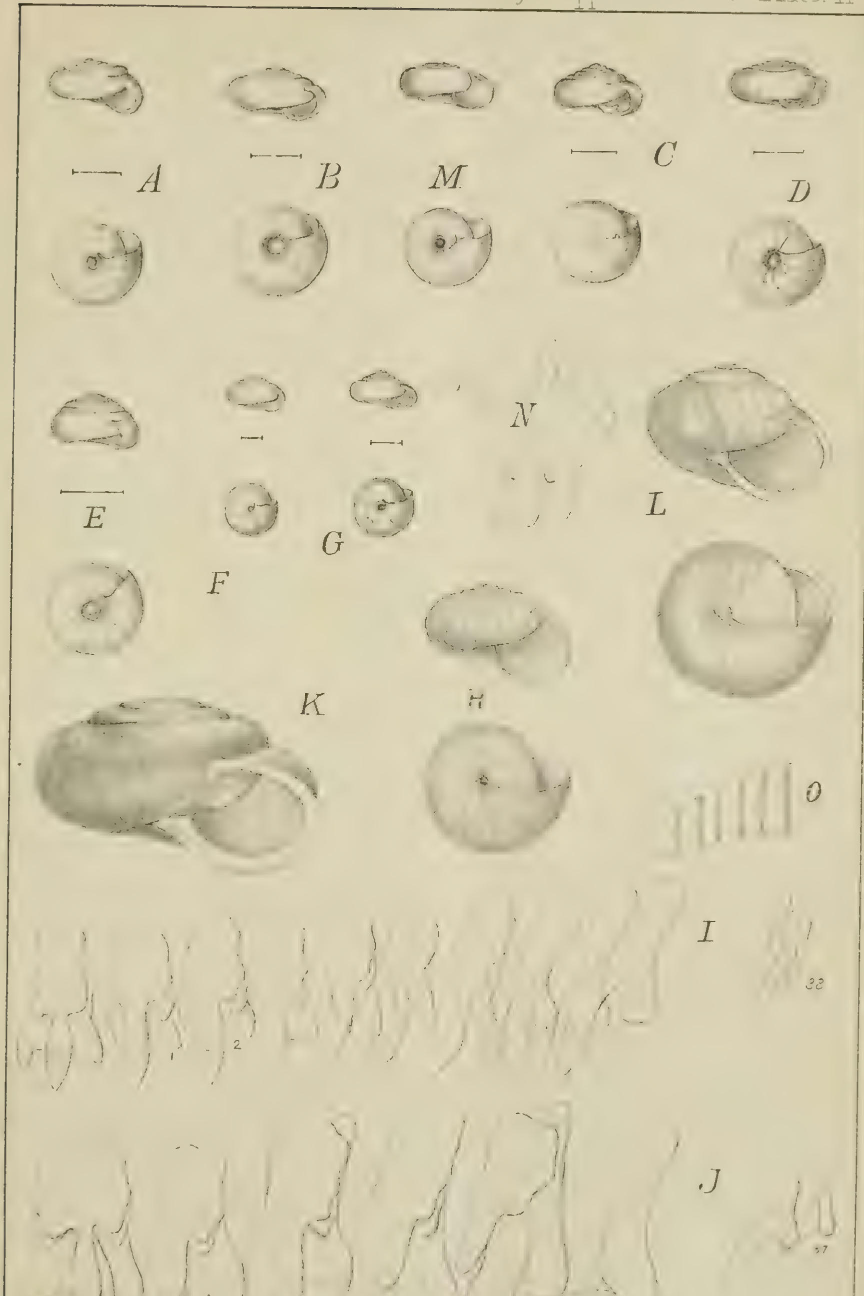
Fig. A. Mesodon Andrewsi, *var.*
" B, C. Aglaia infumata, denuded of hairs.
" D. Glyptostoma Newberryanum.
" E. Arionta Townsendiana, *var.* ptychophora.
" F. " " *var.*
" G. Fac-simile of original figures of Hyalina subrupicola.
" H, I. Aglaia fidelis, *var.*

All but B, C, and H, I, photographed from nature.

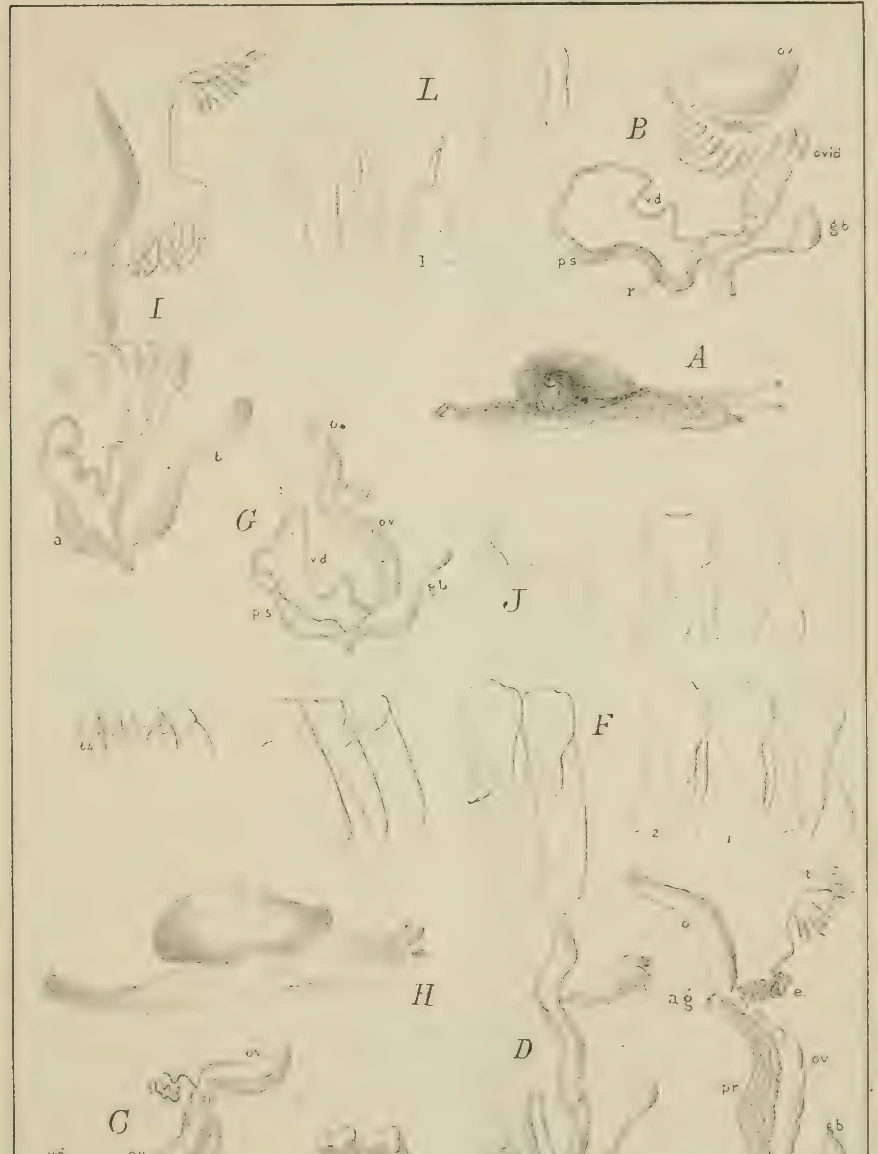


Arthur F. Gray & W. G. B. del.

J. H. Bufford's Sons Boston

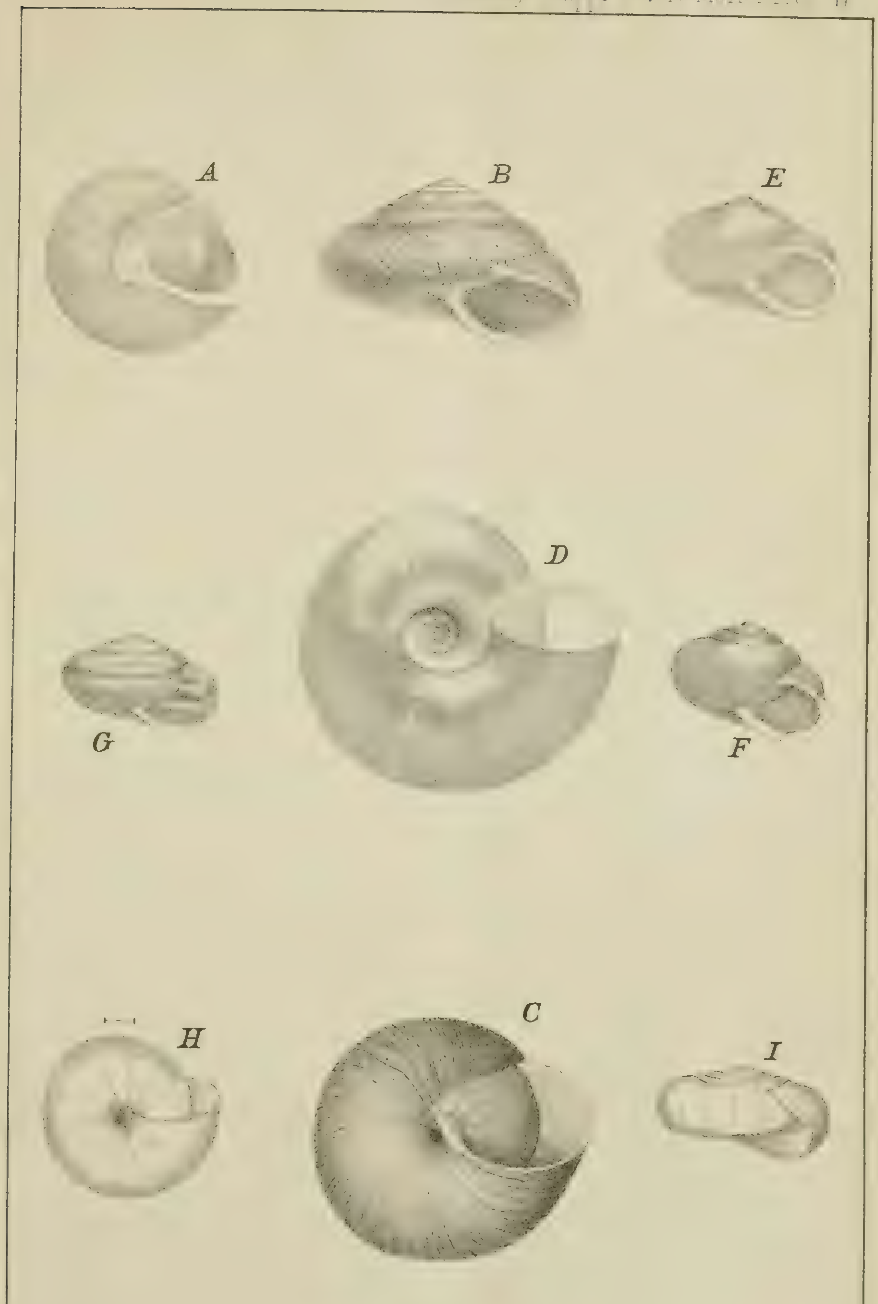


Arthur F. Gray & W. G. B. del.



Miss Pringle & W.G.B.del.

J.H. Bufford's Sons Boston.


A
B
E
D
G
F
C
H
I

No. 9. — *Studies from the Newport Marine Zoölogical Laboratory. Communicated by* ALEXANDER AGASSIZ.

XIII.*

On the Development of Certain Worm Larvæ. By J. WALTER FEWKES.

Prionospio tenuis VERR. (?).

Plates I. and II.

The youngest larva (Pl. I. Fig. 1, Pl. II. Fig. 7) of this worm has a transparent head and a body which is 2–3 mm. long, tapering uniformly from anterior to posterior extremity. The head (Pl. I. Fig. 1) has four eye-spots, or

* The present paper, which is the first to appear under the above title, is one of a series from my Newport Laboratory, of which the following have already been published: —

I. The Development of Salpa. By WM. K. BROOKS. pp. 58. 34 cuts. March, 1876. Bull. Mus. Comp. Zoöl., Vol. III. No. 14, p. 291.
II. On the Young Stages of some Osseous Fishes. By A. AGASSIZ. I. Development of the Tail. pp. 10. 2 plates. 1877. Proc. Amer. Acad., Vol. XIII. p. 117.
III. The Development of Lepidosteus. By A. AGASSIZ. pp. 11. 5 plates. 1878. Proc. Amer. Acad., Vol. XIV. p. 65.
IV. On the Young Stages of some Osseous Fishes. By A. AGASSIZ. II. Development of the Flounders. pp. 24. 10 plates. 1878. Proc. Amer. Acad., Vol. XIV. p. 1.
V. On some Young Stages in the Development of Hippa, Porcellana, and Pinnixa. By WALTER FAXON. pp. 16. 5 plates. April, 1879. Bull. Mus. Comp. Zoöl., Vol. V. No. 11, p. 254.
VI. On the Development of Palæmonetes vulgaris. By WALTER FAXON. pp. 27. 4 plates. September, 1879. Bull. Mus. Comp. Zoöl., Vol. V. No. 15, p. 303.
VII. Contributions to a Knowledge of the Tubular Jelly-Fishes. By J. WALTER FEWKES. pp. 20. 3 plates. March and April, 1880. Bull. Mus. Comp. Zoöl., Vol. VI. No. 7, p. 127.
VIII. On some Points in the Structure of the Embryonic Zoëa. By WALTER FAXON. pp. 7. 2 double plates. October, 1880. Bull. Mus. Comp. Zoöl., Vol. VI. No. 10, p. 159.
IX. Studies of the Jelly-Fishes of Narragansett Bay. By J. WALTER FEWKES. pp. 42. 10 plates (3 double). February, 1881. Bull. Mus. Comp. Zoöl., Vol. VIII. No. 8, p. 141.
X. On the Development of the Pluteus of Arbacia. By J. WALTER FEWKES. pp. 10. 1 double plate. May, 1881. Mem. Peabody Acad. Sci., I. 6.
XI. On the Acalephæ of the East Coast of New England. By J. WALTER FEWKES. pp. 19. 1 double plate. April, 1882. Bull. Mus. Comp. Zoöl., Vol. IX. No. 8, p. 291.
XII. On the Young Stages of some Osseous Fishes. III. By A. AGASSIZ. pp. 32. 20 plates. 1882. Proc. Amer. Acad., Vol. XVII. p. 271.

ALEXANDER AGASSIZ.

ocelli, each of a reddish color. Two of these are placed near the median line, and two appear near the bases of appendages called cephalic tentacles (*t*), Both pairs are situated in the dorsal walls of the head. In the cephalic walls below the median eye-spots there is a greenish spot of triangular shape. Similarly colored spots are also situated in the dorsal walls of the head under the lateral eyes.

Two pairs of appendages, known as the cephalic tentacles (*t*) and the cephalic setæ (*s*), arise from the head. Both of these cephalic appendages are embryonic.

The tentacles (*t*) are long, flexible bodies, which are sometimes closely coiled about their bases, and at other times widely extended. These appendages are transparent, of a slightly reddish color, and unjointed. Their surface is covered with short stiff spines or hairs, which are especially numerous near their distal extremities. Each appendage has a cavity throughout its length, opening into the body cavity, and through the walls the circulation of a fluid contained within can be easily seen. There are two of these cephalic tentacles, both of which arise from the dorsal region of the head, a little above the lateral lines of the body. They are probably homologous to dorsal cirri.

The cephalic setæ (*s*) are smooth, easily deciduous spines projecting from ear-like lappets on the dorsal side of the head below the cephalic tentacles. Their length varies, but in young specimens it is about one half that of the body. Although generally carried separated in a fan-like manner, they are often folded closely together, parallel with the sides of the body (Fig. 6). The cephalic setæ are probably homologous with the embryonic spines of (*Nerine*) *Spio*, and may be regarded as the setæ of a single segment of which the head is formed. It is a significant fact that these spines, as far as known, are only found in those annelid larvæ which are free swimming. In the young *Arenicola*, for instance, which passes its youth enveloped in a mass of slime, these embryonic spines never appear. This fact leads one to ask if they are not special organs for defence rather than ancestral features descended from fossil forms, which according to A. Agassiz they sometimes closely resemble. Their peculiar positions when a *Nerine* or *Prionospio* larva is alarmed leave no doubt of their defensive function.

The mouth is terminal and slightly ventral. The proboscis is short when retracted, not extending back of the posterior part of the head. It is protrusile even in this early condition, and bears a chætinous (?) toothed body of red color, visible through the mouth opening. The position of the posterior extremity of the proboscis is marked by a pair of diverticula (*g*) from the intestinal tract, whose walls are here pigmented with brown and yellow. They lie near the medial dorsal line, one on each side of the junction of proboscis and œsophagus. These "glands" begin to form as small lateral diverticula from the œsophagus, and extend forward in the body cavity, one on each side of the proboscis. Later in their growth yellow pigment appears in their walls, and they assume a superficial likeness to glands. In the dorsal medial line, upon the intestinal tract between them, there is a pulsatile sac

opening into a large anterior vessel. The pulsatile sac resembles a heart; the vessel opening from it, an artery which may distribute blood to the head and cephalic tentacles. Of the true homology of these organs there is, however, some doubt.

The body of the youngest *Prionospio* (Fig. 1) is composed of nine anterior segments, bearing as many pairs of long provisional setæ and four smaller terminal segments without spines. Consequently, it will be seen that in the youngest larva two segmented regions can be distinguished in the body; the anterior (*a r*) forming its great mass and bearing provisional setæ, and the posterior (*p r*) relatively almost inconspicuous in size and without spines. The terminal segments of the latter are colored by bright red pigmentation. The diameter of the intestinal tract narrows uniformly from the head to the anal extremity, with little variation in different regions.

Marked changes of most important character have taken place in the head and body of the next oldest larva (Figs. 2, 3, 4, 5). The arrangement of the tentacles, setæ, and eye-spots on the head is about the same as in the former larva, and the dorsal walls have extended forward above the mouth into a lip which had a rounded border, forming a structure which persists into the adult, and will be called, in subsequent larvæ of this worm, the præoral lobe. This nomenclature, however, does not imply that it is homologous with the structure which has the same name in certain other Annelid larvæ. The body of this larva has dropped, either normally or abnormally, most of its embryonic setæ, and three regions, an anterior, a middle, and a posterior, have differentiated themselves in it. Almost the whole of the body is still taken up as formerly by the anterior region. The middle region (*m r*) is smaller than the anterior, has its walls more thickly pigmented, and retains the embryonic setæ even when the larva is kept in confinement for some time. This region is formed from the originally undivided posterior part of the former larva. The posterior body region is the smallest of the three, and is the same as the nonspinous part of the body of the youngest larva.

The anterior region of the body in the present larva is composed of nine segments, the lines of separation between each pair of which, however, are not well marked. The lateral spines of this part are short and small. The body walls are very transparent. On the sides of the body near the fourth pair of spines there is a cluster of reddish pigment spots (*m s*), which persist even into the oldest larvæ which have been taken (Fig. 13).

The middle body region, which is developed from the original posterior portion, is formed of four segments, the constrictions between which are deep and well marked. The segments are sometimes swollen to a diameter greater than that of the transparent anterior portion of the body. The walls are thicker than those of the transparent part described above, and are more densely pigmented with yellow and brown. That portion of the digestive tract which lies in the middle body division is here considered the stomach. The posterior division of the body has a smaller diameter than either of the others, and is without appendages. It is, however, segmented, and later in its

growth becomes spiniferous. The terminal segments bear small papillæ, and are colored with crimson pigment.

The next following larvæ (Figs. 6, 7, 8, 9), which are slightly more mature than the last, differ from it in several particulars. The most important changes which have taken place in the form of the head (Fig. 9) are an antero-posterior lengthening of the whole segment of which it is formed, and a still greater projection of the præoral lobe, which also becomes more pointed. Perhaps the most significant of the general changes which have occurred is the appearance of a basal joint in the cephalic tentacles. These appendages, which in all the younger larvæ are almost uniform in size throughout, in this are found to be marked at a short distance (*b f*) from their origin with patches of red pigment. The color is first seen on the anterior wall of the appendage. The walls of the tentacle, where this pigment first appears, are somewhat thickened, and a slight corrugation forms on the tentacle at this point (Fig. 9).

The body of the larva has meanwhile become more elongated, and two additional bundles of setæ have arisen on each side in the anterior or transparent region of the body. The backward growth, leading to an increase in the distance between the "glands" (*g*) found at the posterior part of the head and the cephalic tentacles, has greatly increased, while the size of the "glands" has diminished. The portion of the intestinal tract which lies in the transparent anterior region of the body, between the glands mentioned above and the first of the four segments which compose the middle body region, fills most of the body cavity, and lies on the dorsal side. Each parapodium of the anterior body region is double, consisting of a dorsal and ventral protuberance, both bearing a small bundle of setæ. The parapodia of the middle and posterior regions have a single protuberance of similar character.

The general appearance of a larva a little older (Figs. 10, 11) than the last is somewhat different by reason of the loss of the temporary embryonic setæ (*s*) formerly found on the head. It is extremely difficult to indicate definitely the time when these bristles normally disappear, but it is probable that the disappearance takes place when the larva is in about the condition figured in Fig. 11. The internal modifications of structure which have taken place in passing into this larva are important. The diverticula ("glands," *g*) mentioned above have changed their position relatively to the crimson pigment spots (*m s*) of the fourth pair of bristles. They are now situated in the same segment as these spots, and a diameter connecting opposite clusters of setæ passes through them both. Important changes have also taken place in the cephalic appendages. The basal portion (*b t*) of the tentacle has enlarged at the expense of the distal, which is the remnant of the embryonic appendage. Fully one half of the old tentacle (*t*) now enters into the formation of the new basal joint, which ultimately becomes a permanent cephalic appendage. The distal end of the same is not changed from the condition which it formerly had. The corrugations of the anterior wall of the basal joint have risen into small appendages, which gradually increase in size as one compares those found near the head with those at the

distal end of the joint near its articulation with the distal article. These appendages cease at the point of division between the basal and terminal joints. Patches of reddish pigment are found at intervals corresponding with the positions of the parapodia along the anterior region of the body. Although their color is less conspicuous on other segments than on the fourth, it is as a general thing best marked on the anterior somites. The protuberances ("auricles") from which the embryonic spines (*s*) of the head formerly arose, are also marked with crimson (Figs. 10, 11).

In this stage, the peculiar crochet spines (*c h*) hanging to the posterior region of the body first appear.* On each segment three pairs of these bodies were counted. They arise from the dorsal region of the parapodium. In addition to these appendages the posterior body segments also bear on a ventral elevation smooth spines similar to those on the anterior and middle regions of the body. Later, the hook-like setæ (Fig. 13, *b*) appear on the segments of the middle body region, and rudiments of them may exist in the middle division of the body of the larva we are considering.

The last segment of the posterior region of the body (Fig. 12, *a*) has an oval elongated shape, and is dark red in color. It is flattened ventro-dorsally, broadening into small lateral expansions. Minute papillæ are found on the terminal segment. The anterior body region is now formed of nine, the middle of five, and the posterior of ten segments. The oldest larva of *Prionospio* which was found (Fig. 13) was raised from the last, and differs from it in many particulars. The præoral lobe (*p l*) is much larger and more prominent than formerly. The cephalic tentacles have wholly absorbed the embryonic appendages, whose place they now occupy, appearing as two tentacular bodies with appendages (branchiæ ?) on their anterior outer walls. The tentacles found on the head in the youngest larva have been wholly absorbed into the proximal joint (*b t*). The separation between the middle and posterior divisions of the body is not as well marked in the oldest larva as in those which we have already considered. The posterior limits of the anterior division is easily recognized from its transparency. Although this portion is more transparent, its division into different segments is not as evident as in the middle region. It bears nine bundles of setæ, arranged at regular intervals on each side, and we may regard it as made up of nine segments.

Each parapodium consists of a dorsal and ventral prominence, upon each of which there is a small bundle of setæ. The cluster of crimson (*m s*) opposite the fourth bundle of spines is still well marked. The "glands," which in earlier larvæ were so prominent, have in this very much diminished in size, or completely disappeared.

The intestinal canal does not now occupy comparatively so large a part of

* These spines were first noticed in a larva of this age. They may have escaped observation in earlier larvæ. The embryonic spines of all Annelid larvæ easily fall off when kept in confinement, and there is no uniformity in the appearance of the larva when they disappear under these conditions.

the cavity as formerly, and its course is more tortuous, especially in the posterior region of the body, than in the preceding. Not only have the temporary cephalic bristles fallen off, but also the long spines found on the body have been replaced by shorter and less conspicuous setæ. The most persistent of these deciduous spines are situated in the middle region of the body. In this larva, however, these have given place to minute bristles, and to the "crochet hooks" (Fig. 13, *b*) of the terminal region. I am inclined to think that the temporary body bristles are confined to that portion of the body which is described above (Fig. 1, *a r*) as the anterior region.

The colors of the oldest larva (Fig. 13) are similar to those of the younger. The præoral lobe has little color except in the green regions near the eye-spots. There is in the cephalic dorsal walls, in front of each of the lateral eye-spots, a hemispherical green body. Just below and in advance of the median pair of eye-spots there is a body of the same kind, which has a median prolongation extending nearly to the anterior margin of the præoral lobe. The cephalic tentacles are reddish in color. The lateral lobes on the head, from which the spines formerly arose, are likewise red. The body of the worm is green and brown, with red pigment spots.*

The temporary cephalic tentacles are homologous with the dorsal cirri, while the temporary setæ are strictly the same as those found on the segments of the body.

It will later be seen, in a description of the young (*Nerine*) *Spio*, which likewise has embryonic spines on the head, that two long dorsal cephalic appendages or tentacles also exist in this genus. Here likewise these bodies may be regarded as homologous with dorsal cirri, and as belonging to the same segment as the embryonic cephalic spines, which are later dropped. The median and lateral antennæ and the palpi are not represented in *Prionospio*. From this absence of the appendages last mentioned, we are not to suppose that they indicate in *Lepidonotus* a larger number of cephalic segments than that which exists in *Prionospio*.

In the account given above, the two long appendages to the head are called tentacles, from the fact that in younger larvæ they resemble so closely the tentacles of other Annelides, especially those of the *Spionidæ*. In function, however, they are probably in later larvæ branchiæ, and ultimately assume a form approximating that of the branchiæ in other Annelides. In the growth of the worm, additional branchiæ must also be formed, if we are right in our reference of this larva to *Prionospio*. Intermediate larvæ between that last mentioned and the adult may show that a new identification must be made, and that the larvæ do not belong to *Prionospio*.

* Professor Verrill has kindly examined some of my sketches of this worm, and writes me that they can perhaps be referred to the Annelid which he has mentioned in Amer. Jour., November, 1882, under the name of *Prionospio*. (See also Trans. Conn. Acad., Vol. IV., Pl. XXVII. Fig. 3.)

Spio sp.

Plate II.

The embryos of a species of *Spio* are among the most common larval worms found at Newport. They are very characteristic in form, and on that account are seldom confounded with the larvæ of other genera.

The youngest *Spio* (Fig. 3) is telotrochal, and has a large, præoral lobe bearing an equatorial ring of cilia and embryonic spines, which arise from ear-like backward projections of the head. There are no paired cephalic appendages, and no cephalic eye-spots, although scattered pigment marks the future position of the latter organs on the dorsal region of the head. The embryonic spines are about double the length of those on the body. Each embryonic spine, even when slightly magnified, is found to bear small lateral spurs at regular intervals along its length. When the larva is alarmed, the spines are raised, and project at all angles to their point of origin.

The body is unsegmented, and, like that of other telotrochal Annelid larvæ, bears at its posterior end a ring of vibratile cilia, which arise from a thickly pigmented caudal segment.

In a larva still older * (Fig. 1) than the last, several marked changes have occurred. One of the most important of these is a division of the body into somites, although no parapodia are yet visible along the lateral lines. When seen from the dorsal side, the ridge which bears the ring of cilia will be observed standing out more prominently from the body than in early conditions. Along the anterior or upper part of this ridge there is a row of pigment spots. Slightly removed from the median line, and a little in advance of the ciliated ridge last mentioned, there are four eye-spots, called lateral ocelli. An additional pair of median eye-spots is placed near together on a slight backward extension of the head, behind the ciliated ridge. These, apparently, are wanting in a similar larva of *Nerine*,† of about the same age.

The cephalic appendages (Fig. 2) are short and blunt, and have a length of about one third that of the body. They correspond to the dorsal cirri of the segment which forms the head. Small ventral cirri of the same segment are also found on the same side of the head as the mouth. The body consists of five segments and a terminal joint, which bears a well-marked circle of anal cilia. Each intermediate body segment is pigmented in the following pattern. When seen from the dorsal side, five narrow parallel bands of black pigment extend across the body in the interval between a line on the body opposite the extremity of the dorsal cephalic cirri and the anal circle of cilia. Each of these lines corresponds to a body segment, and, extending through about one

* This larva is of about the same age as that figured and described by Leuckart and Pagenstecher in Müller's Archiv for 1858, Taf. XXIII.

† See A. Agassiz, On the Young Stages of a Few Annelids, Ann. Lyc. Nat. Hist., Vol. VIII., 1866.

fourth the circumference of the body, lies midway between anterior and posterior border. Five similar lateral lines of black pigment alternating with those of the dorsal region are found on the sides of the larva. These markings are placed in two lines, and are found on each segment, but do not join the dorsal series of markings, since they are placed in different regions of the body segments, which are not continuous. On the ventral side of the larva, similar lines of black pigment also appear; but, instead of extending across the medial line, as the markings on the back, they are arranged in two series of parallel markings, of which there is a row on either side of the median line.

The number of segments in the next oldest larva has increased to seven, or, if we include the terminal, to eight. The pattern of color in each segment is the same as that in the younger larva already described. In this, the number of pigment spots on the head has also increased. At the base of the cephalic appendages, near their origin under the ciliated ridge, more especially in the ear-like protuberances ("auricles") which carry the embryonic setæ, there will also be noticed prominent patches of crimson pigment.

Spines indicating the position of future parapodia have appeared in the body segments, although the lateral protuberances are still quite small. The spines of the penultimate segments in many specimens are much longer than the others. The intestinal tract, with the exception of the bend which the œsophagus makes just before it opens into the stomach, follows an almost direct course from the mouth to the vent. The lips and walls of the œsophagus are richly ciliated. The external walls of the body are sparsely covered with small black pigment dots.

Aricidea sp. (?).

Plates II. and VI.

A series of larval Annelides referred to the genus *Spio* has been described by Claparède and Metschnikoff.* The youngest larva, which is here considered the young of *Aricidea*,† closely resembles the oldest which they describe.

The youngest larva of this genus has a close likeness to the young *Spio* (p. 173), but differs from it in having three pairs of setæ, one upon the head, a second on the body at about two thirds the distance from the mouth to the posterior end of the body, and a third at or near the posterior terminal segment. In very young larvæ these spines are very short. The head is more rounded than that of *Spio*, but like it has two ear-like lappets from which the temporary bristles below the ring of cilia arise. There are no eye-spots, and instead of well-bounded ocelli irregular patches of pigment are found on the dorsal surface of the head in a position where eye-spots are later to be seen.

The temporary head bristles are smooth, and destitute of the lateral spurs

* Zeit. Wiss. Zool., XIX., 1869.

† *Aricidea* Webster is not found in our waters. It was taken by H. E. Webster on the Virginian coast. Trans. Albany Inst., Vol. IX., 1879.

already spoken of in *Spio*. There is no well-defined ciliated cephalic ridge bounding the præoral lobe. The body is divided into two segments by a deep constriction just in advance of the first of the two bands of body cilia. The segment which forms the anterior portion of the body shows a number of annulations; the posterior part of the body is thickly pigmented in irregular patches. The final segment bears laterally a pair of long setæ, which extend backward beyond the posterior end of the body. The anterior body segment seems destitute of lateral spines. Bands of black pigment mark the position of the two circles of cilia which accompany the body segments.

In the next oldest larva, raised from the last, we find that the body has become more elongated, and is now marked with two deep constrictions forming three body segments. The anterior of these is crossed by a number of lines forming the annulations to which reference has already been made. The second bears a pair of lateral setæ and a band of pigment. The third body segment carries two ciliated rings, each encircled with bands of pigment. That portion of the head which is in advance of the irregular patches of pigment already mentioned bears a small band of cilia.

An older larva has a body even more elongated than those already described, which is divided into four segments, the first and second of which bear lateral spines. Two pairs of ocelli have differentiated themselves from the irregular masses of pigment formerly found in the dorsal walls of the head.

The next oldest larva was not raised from the last, but has so many resemblances to it that it seems identical with the larvæ already described.

The head has the same general form as that of the preceding, although the præoral lobe is less prominent. It has four eye-spots. The body is divided into fifteen segments, each with lateral spines, and a single terminal segment which is destitute of these bodies although richly ciliated. The spines of the anterior segments are much longer than those of the following. Almost the whole interior of the body is occupied by a stomach, which narrows abruptly in the twelfth segment, passing into a tubular uncoiled intestine. The head of a larva (Pl. VI. Fig. 10) following the last in age is different from that of its predecessor, in possessing a single median antenna (*m t*). The body of the same has fifteen segments, and still retains the embryonic setæ, although their length has very much diminished. The head bears four eye-spots. The cephalic auricles as well as the terminal body segment are still richly ciliated. The stomach ends in the neighborhood of the tenth body segment. The intestine is narrow and straight.

The loss of the embryonic setæ of the head occurs at about this age in the growth of the worm, and in a larva of about the same age as the last, having still fifteen body segments and a ciliated caudal one, these long spines have fallen off, leaving the cephalic "auricles" projecting prominently outward back of the head and in advance of the anterior body segment. This is the oldest larva of the series which was taken.

The above history of the larvæ which are referred to *Aricidea* is of interest on account of the fact that the worm has in the oldest larvæ the long pro-

visional setæ, yet wants the other cephalic appendages of the larval *Spio*. In other words, the appendages, which have been homologized with the dorsal cirri of a head segment, are never developed in this genus, while the spines are formed only to disappear in subsequent growth of the worm as it matures. The median antenna and other cephalic appendages are subsequent growths, and may be looked upon as appendages of the originally single segment.

Polytrochal Larva.

Plate VI.

A single polytrochal larva was taken about the end of the summer. The body is elongated, wormlike, and bears on the sides of the head two flat circular ear-like appendages ("auricles"). Two small well-marked median cephalic eye-spots are well developed. There are no tentacles, palpi, nor tentacular cirri. The rudiments of two appendages resembling tentacles yet of a circular shape point to a relationship between this larva and some member of the *Spionidæ*. The body is composed of twenty-four segments. The posterior terminal body segment ends in two protuberances. Each of the body segments is pigmented on its posterior border. Along the dorsal region of the larva there is also on the median line a similar although larger mass of pigment. There are ten small pigment spots, ring-shaped and of black color, which are placed at regular distances on one side of the body. Each lies on a ciliated segment, and is situated in a median line on the ventral side of the larva.

The pigmental rings (*p r*) on the ventral side of the body of the above-described polytrochal larva seem to have a morphological meaning. At the same time with our collecting of *Spio* larvæ we captured many young worms (Figs. 2, 3, 4), which in outward appearance resemble very closely the older stages in the growth of the same. These larvæ, however, have one very interesting difference, which allies them more intimately with the polytrochal larva described above. As in many Annelid genera, *Phyllodoce*, *Prionospio*, *Telepsavus*, and others, the fourth body segment is modified by the introduction of different-shaped spines, or by pigmentation of the body walls, we naturally expect in other genera to find this segment individualized as compared with its neighbors. In a worm larva, somewhat resembling the polytrochal just described, we find on the ventral side of the fourth body segment a pair of pigmented eye-spots (ocelli?), and that the fourth body segment bears a belt of large cilia similar to those found on the head and caudal extremity. While we recognize in these pigment spots the homologue of the ring-shaped pigmented regions in the median ventral line of the polytrochal larva, we can see in this larva an intermediate larval form between the telotrochal and polytrochal conditions. The pigment spots are probably homologous with the pigmented regions (*m s*) already described in *Prionospio*, where, however, they are forced more laterally, and the ciliated ring on the same segment is lost.

Telepsavus (?).

Plates III. and VIII.

The most common mesotrochal larva at Newport is similar to one supposed by Claparède and Metschnikoff * to be the young of *Telepsavus*. The adult *Telepsavus* has not been found in Narragansett Bay, and the allied genus *Spiochætopterus*, to which Dr. E. B. Wilson † doubtfully refers larvæ from the Chesapeake Bay with many points of resemblance to those which are about to be described, has also not yet been recorded from the locality where my studies were made.

A very common worm larva, which has the whole surface ciliated and an apical compound flagellum, but in which no equatorial ring of cilia had formed, is very commonly found at Newport in our dip-nets. These larvæ (Pl. VIII. Figs. 12, 13, 14) resemble closely the young of *Chætopterus*, but are larger, and in older stages more elongated. They resemble closely the young *Telepsavus* figured by Claparède and Metschnikoff, and on that account are here referred to this genus, although they have not been raised into any member of the present series. They might equally well, however, be connected with the larvæ which have been identified as belonging to the closely allied genus *Phyllochætopterus*.

The young *Telepsavus* (Pl. III. Figs. 6, 7) is quite large as compared with other Annelid larvæ, and can with the unaided eye be easily distinguished swimming about in the water. The body is swollen into an almost globular shape, and is divided into two regions by a mesial ring of cilia. In the youngest stages of growth neither of these divisions is segmented. A fleshy triangular lobe, rounded in front, is largely developed, and extends beyond the mouth on the dorsal side of the head. The lower lip is bilobed. There are two cephalic eye-spots in the youngest larva. The whole body is covered with cilia, and a prominent median cilium is found on the præoral lobe near its rim. The mouth (*m*) has a triangular shape, opening below the lobe, and is surrounded by fleshy lips. No tentacles or cephalic appendages are yet developed.

The posterior portion of the body is short, tapering to the posterior pole of the larva, which bears a segmented (?) tail (Fig. 7, *a*). The anus is dorsal in larvæ of this age.

Almost the whole interior of both cephalic and caudal regions of the body is taken up by a large cavity (*s*) called a stomach, which occupies the greater part of the anterior body region, and extends a short distance into the posterior part. Its walls have a green color, while those of the body are brown and pink. A diverticulum from the stomach extends forward in the ventral region of the body cavity below the œsophagus. The œsophagus in its course bends twice upon itself, and opens into the stomach on the dorsal side. Its walls are

* Zeit. Wiss. Zool., XIX., 1869.

† Observations on the Early Developmental Stages of some Polychætous Annelides, Stud. f. Biol. Lab. Johns Hopkins Univ., Vol. II. No. 2.

thicker than those of the stomach. The intestine is short, slightly coiled, and opens externally through a dorsal anus. The "ventral gland" (*v g*), indicated by a depression in the external body wall on the ventral side of the anterior body region, has not yet appeared.

The above larva is easily distinguished from the young *Phyllochætopterus* (Fig. 16) of about the same age, by the absence of dorsal median eye-spots near the long cilium on the præoral lobe of the head.

In the next oldest larva (Fig. 5) of *Telepsavus*, we find that a new pair of lateral eye-spots has formed, and two slight projections, one on each side, at the base of the head, now appear. These last-formed bodies are the beginnings of cephalic appendages, which later attain a great development. In other particulars, the two larvæ differ very slightly from each other.

The next oldest larva (Figs. 8, 9) to that last described is one in which we have few changes, except those which result from the growth of the cephalic tentacles. Segmentation of the body has begun in the posterior hemisphere, but it has not yet appeared in the anterior. The present larva is almost identical with one of those figured by Claparède and Metschnikoff.*

A larva somewhat older (Figs. 10, 12) than that last mentioned shows more striking resemblances to other Annelid larvæ than any of those which have been spoken of above. Anterior and posterior portions share about equally in the elongation of the whole body. Very slight changes have taken place in the head, although the præoral lobe has elongated and become more prominent, and the median cilium has fallen off.

On the ventral side of the body, a deep infolding ("ventral gland," *v g*) of the body wall has taken place, at a point about one third the distance from the ciliated belt to the front edge of the lower lip. Eight simple lateral protuberances, each bearing a small cluster of spines, are found in the interval between the cephalic appendages and the ring of cilia. On the fourth of these parapodia, counting from the anterior, there are spines (*m s*) which can be homologized with the cluster of spines on the fifth segment of *Polydora*.† These bodies occupy in *Telepsavus* nearly the same position as the crimson pigment spots (*m s*) near the "fourth segment" in *Prionospio*. The portion of the body behind the equatorial ciliated circle has become segmented. The segmentation constrictions are clearly defined, especially on the ventral side of the body. Two pairs of lateral branchiæ (*b*) appear on the segment just behind the ring of cilia, and a single pair on the following.‡ These appendages are richly ciliated over their whole surface. The œsophagus (*a*) extends through the anterior part of the body cavity from the mouth to the seventh segment of the

* *Op. cit.*

† In *Polydora*, according to A. Agassiz, these spines are found on the fifth segment, which is really the fourth body segment if we regard the head as a single somite. The clusters of red pigment in *Prionospio* are also found on the fourth body segment.

‡ In Dr. Wilson's larva "two pairs of branchiæ" appear "on each of the two segments behind the thickened ciliated ring."

anterior body region. The stomach (*s*) fills most of the body cavity from that point to the sixth segment of the posterior region. The intestine (*i*) is coiled in the posterior part of the body cavity behind the stomach. The anus, as before, opens dorsally. The "tail," a median terminal appendage, is segmented and slightly enlarged at the distal end into a knob or button.

The oldest larva (Fig. 11) gives no more definite information than others already known in regard to the genus to which it belongs.* The posterior part of the body of this larva is swollen, leaving the band of cilia about midway in its length. The præoral lobe has become more contracted, and the external surface of the body is covered with small papillæ. Another pair of pigment spots — the cephalic eye-spots — has been added to the two already existing. The cephalic appendages have elongated so that their tips extend downward to the vicinity of the ring of cilia. There are now ten parapodia in the anterior region of the body between the cephalic appendages and the band of cilia.

The posterior portion of the body is almost hemispherical. The median anal appendage is greatly reduced in size, appearing as a slight projection, on either side of which there are similar lateral knobs. The intestine is slightly coiled, and lies wholly in the posterior body cavity.

Phyllochætopterus sp.

Plate III.

The youngest larva (Figs. 16, 17), of this genus which we have obtained resembles closely a young *Telepsavus.* It is mesotrochal, and has a large præ-oral lobe, which, like that of the older form of the same figured by Claparède and Metschnikoff,† bears six eye-spots upon the dorsal region. These eye-spots consist of a pair of median and two lateral ocelli on each side. The oral lobe carries on its rim, just in advance of the median pair of ocelli, a flagellum, as in *Telepsavus.* The young *Telepsavus* has four eye-spots; the median pair failing even in a larva in which the tentacles have begun to form on the sides of the head. The youngest *Phyllochætopterus*, even when it has developed into a larva possessing six eye-spots, is still destitute of lateral cephalic tentacles.‡

* Professor Verrill (Trans. Conn. Acad., Vol. IV., Pl. XVIII. Figs. 16, 17) figures this larva, and in MS. explanation of plates, which he has kindly sent me, refers it doubtfully to *Spiochætopterus.* His larva is a little younger than that which is here figured in Fig. 19.

† *Op. cit.*

‡ The Annelid larva (*Mesotrocha sexoculata*) described by Johannes Müller (Müller's Archiv, 1846), by Busch (Ibid., 1847), and by Max Müller (Ibid., 1855), seems more closely allied to this than to the preceding (*Telepsavus larva*). Like the *Phyllochætopterus larva*, it has six eye-spots and two mesial rings of cilia separated by a wide segment. In the figures, however, which are given by the above-mentioned authors, there is no representation of a tuft of cilia (flagellum) situated on the præoral lobe between two of these eye-spots, as is mentioned in the larvæ of

The body of the youngest *Phyllochætopterus* is divided into a large thick anterior, and a smaller posterior region. The mouth opens as a triangular slit on the ventral side, near the anterior extremity of the former. The posterior extremity of the posterior region of the body bears a short median appendage. The mesial band of cilia thus separates the body of the larva into two regions. The anterior of these, which lies in advance when the Annelid is in motion, has a slight depression in its ventral region which marks the position of the "glandular body" described in the larva of *Telepsavus* (and *Spiochætopterus*). The œsophagus, stomach, and intestine can easily be seen through the walls of the body. The anus opens on the dorsal side of the posterior body region, just in advance of the medial caudal appendage. A still older larva (Fig. 18) shows one in which two rows of cilia, separated from each other by a broad segment, are well developed. A segmentation of that part of the posterior body region which is behind the smaller ring of cilia, as well as the more elongated form of the whole larva, is to be noticed in this worm. No cephalic tentacles have yet formed, and the external surface of the body is still covered with small cilia. The globular appendage to the posterior region of the body, figured by Claparède and Metschnikoff,* was not observed. The discovery of the youngest of these two larvæ of *Phyllochætopterus* is interesting, as showing how close the resemblance between the youngest known *Phyllochætopterus* † and the so-called *Telepsavus* larva is; or, that the young *Phyllochætopterus* larva has but one ring of cilia between the anterior and posterior openings of the digestive canal, as other mesotrochal larvæ. The second and smaller ring is a later addition.

Nephthys sp.

Plate IV.

The very little which is known of the development of *Nephthys* we owe for the most part to Claparède and Metschnikoff.‡ Larvæ similar to those which they describe, yet in different stages of growth, were raised or fished up in great numbers in our work.

The youngest of these (Fig. 1) are telotrochal, and may be classed with the larva of *Polygordius*. The præoral lobe is very large, and imparts an almost spherical shape to the upper hemisphere of the larva. Equatorially about the larva there runs a ridge upon which a circle of large and powerful cilia is borne. The upper hemisphere or præoral lobe is rounded; the lower more pointed. The whole larva has a green color, is somewhat transparent, and is

both *Telepsavus* and *Phyllochætopterus*, by Claparède and Metschnikoff, and in the present paper.

* *Op. cit.*

† The adult *Phyllochætopterus* has not been recorded in our waters. (See Verrill's Check List.) Chaparède and Metschnikoff's identification of the larva has been followed in my studies.

‡ *Op. cit.*

ciliated on its outer walls. The ridge upon which the large cilia arise is colored light red. At the lower pole near the vent there is a ring of small cilia. No segmentation has yet appeared in the lower hemisphere. There are conspicuous pigment spots in the lateral walls of the præoral lobe, but they appear in irregular patches of red and brown color. The general disposition of the internal organs is easily seen through the transparent body walls. By far the greater part of the interior of the larva is taken up by the stomach (*s*), a globular inflated sac with gall-green colored walls. It occupies most of the interior of the oral lobe of the larva above and in advance of the ciliated equator. The digestive tract communicates with the external water through two orifices. The first of these is a mouth, and the vestibule intermediate between it and the stomach is probably the œsophagus. The mouth opening lies on one side (ventral) of the larva, just below its ciliated equator. The lower lip of the mouth is richly ciliated. The double row of cilia which together make up the prominent mesial ring divides in the vicinity of the oral opening, one half, composed of smaller cilia, passing below the mouth on the lower lip; the other, or larger, skirting the border of the upper lip. The inner walls of the œsophagus and stomach are likewise ciliated. The lower pole of the larva is placed at an unequal distance from the equator measured on ventral and dorsal sides of the body. Almost the whole of the lower part of the cavity of the embryo, below the plane of the equatorial band of cilia, is taken up by the intestine, which is an elongated sac-like body opening into the stomach on one side, and into the external water through the vent on the other.

The pattern (Fig. 1, *a*) of color on the anal pole of the larva is characteristic in *Nephthys*, and on that account has been of great service in identifications of larvæ of different ages, whenever one could not be raised from another. The pigment is here arranged as follows. Two small areas of green color are found on either side of the anal pole. These areas coalesce with each other on the dorsal, and are distinct on the ventral side. Slightly in advance, and removed from them by a colorless zone, there is a narrow parallel band of green, closed on the dorsal, and open on its ventral side, encircling the body. This unclosed band marks the position of an anal ring of vibratile cilia. It persists with the same characteristic form in very late stages in the development of the worm.

The next oldest larva (Fig. 2) to that described has assumed a slightly different form from the last. The body is no longer spheroidal, but the lower hemisphere has elongated to double its original length. In this growth the præoral lobe has taken, comparatively speaking, no share, and still remains of about the same shape as before. A zone of green appears about the pole of the præoral lobe, and most of the scattered cilia on the external surface of the body have disappeared. The lower or body hemisphere, on the other hand, has become elongated and segmented, although no parapodia have yet appeared in the several body segments. The intestine has lengthened considerably. Its walls, as well as those of the stomach, have a green color, as in younger larvæ.

In a larva still older (Fig. 4) the growth of the body hemisphere has gone

on, and new segments have been interposed between the ciliated ridge and the anal pole. A pair of pigment spots (*k*) resembling ocelli, or "eye-dots," appear in the dorsal walls of the præoral lobe. The general appearance of this larva from the ventral side is characteristic. The præoral lobe is no longer hemispherical, but the elevation of the pole and the formation of a circular ridge or zone a short distance above the ciliated equator imparts to it a characteristic shape. The rounded projection or polar elevation of the præoral lobe above this zone is crowned by a cluster or tuft of cilia. A black spot is found on each side of a median dorsal line passing to the apex of this protuberance. The green zone which was formed in the cephalic region of Fig. 2, while the præoral lobe had a regular hemispherical shape, has now increased in width, and the wall in which it lies bulges out, forming a collar about the lobe. This collar has a more greenish color than the rest of the larva. About its lower rim, however, there is considerable black and some red pigment. The mouth lies near the equator, situated similarly to that of the young *Polygordius* ("Loven's larva"), between two rows of cilia.

The most important change which results in passing from that represented in Fig. 4 into the next oldest *Nephthys* (Fig. 5) is a still further elongation of the body, and consequent diminution in size of the præoral lobe. The most important addition is the formation of the parapodia, the spines (Fig. 6, *b*) of which even in this early stage are serrated, like those of the known species of *Nephthys.* The number of body segments is nine. Each parapodium (Fig. 12, *b*) has a dorsal and ventral cirrus, and bears two bundles of setæ, each composed of several short, serrated spines. The form of the stomach and intestine is more elongated than in the earlier larvæ.

A larva a little older (Fig. 6) than that last described, although not unlike it in general contour, differs considerably from it in some particulars. This difference is a result of changes which have taken place in the internal organs. On looking at the larva from the ventral side, the mouth can be seen just below the equatorial ring of cilia. Behind the mouth through the body walls appears the œsophagus, which when seen from the ventral side has a circular profile. Below the mouth, extending to the region of the seventh body segment, is the stomach. At this point (seventh segment) the intestine begins, and from it is continued into the terminal body segment. Just below the junction of the œsophagus and stomach, on the right-hand side of the figure representing a larva of this age seen from the ventral side, there will be noticed an indentation in the stomach walls, forming by the enlargement a space in the body cavity, in which lies a globular sac. The pulsations of the sac in this and subsequent larvæ can be plainly seen through the body walls. The terminal body segment ends bluntly in two lateral prominences, which are colored green. In the median line between them on the dorsal side there is a small unpaired appendage, which persists in subsequent stages into the oldest larva of *Nephthys* which was studied.

Fig. 7 represents a larva of *Nephthys* still older than the last. The whole larva, more especially the body region below the circle of cilia, has become

longer, and additional segments have formed in the body, by which a still greater likeness to the adult worm has been acquired. It is still, however, free-swimming, although sometimes resting upon the bottom of the glass in which it is confined. The penultimate as well as the terminal body segments, are destitute of spines. The œsophagus has lengthened considerably, and through its walls the jaws (*j*) can be easily seen between the third and fourth segments.* The stomach walls are opaque and colored green.

The "pigment dots" (*k*) found on the apex of the præoral lobe have now changed their position in the head, and moved somewhat backward towards the middle of the body. Each lies on the outside border of a transparent body of spherical shape, which touches on the median line of the larva a similar body on the opposite side. Both are situated in the dorsal walls, and are almost invisible when the larva is viewed from the ventral side. The rows of cilia about the neck are very active, as are also those near the posterior end of the body. The head retains its comparatively large size, and is without appendages.

The next stage (Fig. 9) in the development of *Nephthys* shows us one where the reduction in the relative size of the head and body has gone on, and the cilia, which once formed such a prominent feature about the lower part of the former, have almost wholly disappeared. The head bears a single pair of short antennæ. The body is composed of ten setiferous parapodia and a pair of terminal somites, which are without spines. The segments are separated by deep constrictions, and each parapodium is composed of a ventral and dorsal protuberance, both of which bear serrated spines. The ventral cirrus is short and blunt ; the dorsal long and slender.

The œsophagus has elongated to such an extent that its posterior end now extends backward in the body cavity to the eighth segment. The "eye-spots" (*k*) lie in the dorsal walls of the third body segment. When the œsophagus is protruded outside the mouth opening, these bodies retain their relative position as regards the segment, and are not moved with it, which indicates that they are not connected with the digestive tract, as might at first be supposed. The mandibles, with which they might be confounded, lie between the sixth and seventh segments, and can be protruded with the proboscis.

The oldest larval *Nephthys* (Figs. 11, 12) which was observed has ten body segments which bear spines. I was able in one specimen to detect on the head the beginning of a single representative of a second pair of antennæ, although such could be seen only on one side. In this larva, which is shown in Fig. 11, the head is quite small as compared with the body. The distance from the tip of one lateral spine on a body segment to the end of another, on the opposite side of the body, is three or four times the breadth of the middle of the body. The dorsal region of the head has a green color, in which are irregular patches of black and red. The black pigment probably later concentrates into those

* In the oldest *Nephthys*, figured by Claparède and Metschnikoff, they lie opposite the first body segment.

special pigment spots of the head which are called ocelli. The original "pigment dots" (*k*) lie in the third body segment. The point of separation between the stomach and œsophagus is near the seventh and eighth body segments. The formerly enclosed anal ring of green color and the two regions of green pigment on the last body segment have coalesced, so that the whole terminal segment has the same yellow and green color as the head. The intestine is slightly tortuous in its course, and is clearly differentiated from the stomach. Scattered red pigment spots appear on the external body walls along the dorsal and ventral median lines.

The oldest worm in the series described above was raised from the youngest through the successive stages mentioned. Although the larvæ as a rule bear confinement with little discomfort, I was never able to raise them into the adult *Nephthys*.

The identification of the larvæ of a related species by Claparède and Metschnikoff has been followed, since three forms of the larvæ which are here figured will be found to resemble "stages" which they have already represented. The oldest larva which was studied is much more developed than the oldest which they had, and approaches the adult form more closely, which seems to me to add new evidence to confirm the identification which they made. Until, however, it is raised into an adult, or the youngest is traced back to the mother through the egg, the identification must be regarded as provisional. The homology of the black spots originally found on the apex of the præoral lobe, but now in the fourth body segment, is doubtful. The theory that they are homologous with the embryonic otoliths of *Terebella*, has little to recommend it. It is not known whether they are lost in later growth in older larvæ or not.

Claparède and Metschnikoff speak of these "eye-spots" as eyes with lenses, and the neighboring transparent "cells" as brain lobes. In the oldest larva which they represent in their figures (Pl. XIV. Fig. 3, *c*) these bodies are situated in the head. In the oldest larva which is described in the present paper, they lie in the fourth body segment. Similar bodies have been figured by Bobretsky * in the larvæ of *Pholoë*.

The movement of the "eye-spots" from the head into the fourth body segment is probably brought about by the growth forward of the head and the anterior body segments. The means by which this has been accomplished is not, however, perfectly clear.

* КЪ ИСТОРІИ РАЗВИТІЯ АННЕЛИДЪ, Pl. IX. Figs. 3, 4. The copy of this paper which I have used is from Zapiski Kiefskavo Obshto Yestestvoispitatalyei.

Lepidonotus squamatus (?).

Plates III. and IV.

The youngest * larva (Pl. IV. Fig. 14) of this genus is monotrochal. The body has a globular shape, upon which the arrangement of the circle of cilia is not perfectly equatorial. The pole of the cephalic hemisphere is pointed, and bears two eye-spots connected over the dorsal surface of the præoral lobe by a double row of pigment spots. Parallel with the mesial circle or circles of cilia are two rows of pigment spots on the upper and two on the lower (posterior) hemisphere of the body. The lower half of the embryo is more elongated than the upper. The mouth is widely open, and lies just below the rim which bears the larger cilia. The lower lip is fringed with a row of smaller cilia. The interior of the larva is occupied by a stomach, œsophagus, and intestine, which are not clearly differentiated from each other.

The next oldest larva (Figs. 16, 17), *Lepidonotus*, is characteristic.† The body has elongated itself, although it has not yet become worm-like in shape. The oral lobe is hemispherical, without appendages, and bears scattered cilia upon the pole. There are four eye-spots arranged in two pairs. The body bears three pairs of lateral appendages, and the terminal segment is prolonged into two short protuberances. When seen from below, each of these will be found to consist of a single appendage, from which arises a bundle ot spines. Each of these spines ends in a small tooth and a short terminal articulation (Fig. 16, *a*). Upon the back of the larva we find rudiments of the elytra as diminutive circular plates hanging from the bases of the parapodia, which, however, do not cover these bodies. The interior of the larva is taken up by an œsophagus, a large stomach, which fills most of the præoral lobe and extends downward in the body cavity to the second appendage (parapodium), and a long, straight, narrow intestine, which diminishes gradually in size from its union with the stomach to the vent. Cephalic appendages first appear in a larva a little older than the last. (Pl. III. Figs. 1, 2.) The first of these to arise is the median antenna, which first appears as a stout median protuberance of the cephalic walls on the dorsal side of the head between the eye-spots. The larva now has six ocelli, three on each side. The two lateral antennæ form at about the same time, and have at first very much the same general appearance as the single median appendage.

In the oldest larva (Figs. 3, 4) which I have studied all the cephalic appendages have grown more prominent, while the head itself has become considerably reduced in size. In addition to the median and lateral antennæ,

* The larval stages of *Lepidonotus* given above confirm closely in essential points the account of the metamorphosis of *Polynoë* contained in Max Müller's account published in Müller's Archiv for 1851. The segmentation and early development of the egg up to the formation of the monotrochal larva of an Annelid closely allied to Max Müller's *Polynoë* are figured by Sars (Wieg. Arch. 1845).

† This larva was not raised from the former.

two palpi and two pairs of tentacular cirri have also formed. The anal cirri have greatly increased in length, and now resemble simple filaments.

When such a larva is seen from the dorsal side (Fig. 4), four large circular elytra can be observed above the parapodia. The setæ of the lateral appendages of the body terminate in a short joint, as in the youngest larva, which has already been described. Rudiments of a fifth pair of elytra, the next to appear, can be seen just behind the most posterior of those already formed, or between it and the posterior body segment.

The body of the larva is only partially transparent, although an intestinal tract is visible from the dorsal side through the elytra and dorsal body walls. The parapodia are well developed, and eight in number on each side of the body. Each parapodium is single, undivided, and bears a cluster of long bristles and a long dorsal cirrus. Each seta has a terminal joint and a basal articulation, which carries a small tooth, as in the younger larvæ which have been mentioned above. The elytra are still of diminutive size, although they cover the bases of the parapodia. The point of separation between the stomach and the œsophagus lies just behind and beneath the first pair of elytra. The stomach sends off lateral extensions in pairs corresponding to the second, third, and fourth parapodia.*

Larva of Nereis sp. (?).

Plate VI.

The young of a doubtful species of *Nereis* bears upon the head two lateral tentacles, and two short palpi, each with a basal and terminal joint, the latter of which is richly ciliated. There are also upon the head three well-developed tentacular cirri. The dorsal surface of the head has six eye-spots, two of which are placed near the anterior dorsal rim, and four near the posterior. All are widely separated from a median line.

The body is composed of ten segments, nine of which bear pairs of setæ. The parapodia are very prominent.† Each parapodium has a dorsal and ven-

* The young of an unknown Annelid (Pl. IV. Figs. 13, 13[a]) is easily mistaken for the youngest *Lepidonotus* mentioned above. Although monotrochal it wants the paralleled rows of black pigment spots situated above (anteriorly to) and below (posteriorly to) the mesial row of cilia. This embryo is exceptional among monotrochal larvæ, in possessing a single caudal appendage, which is well developed before lateral caudal cirri appear. The unpaired median appendage is not unlike that found in the mesotrochal larvæ of *Chætopterus*, *Telepsavus*, and *Phyllochætopterus*. Does this larva belong to the genus *Harmothoë*, or is it the young of some Bryozoan?

† Compare this larva, as well as the young *Nephthys* (Pl. IV. Fig. 12), in this particular, with the strange genus *Tetraglene* Verr. In respect to its color, size, cephalic appendages, and other particulars, the two are very different. Many specimens of *Tetraglene* have been taken in our work at Newport. (See Verrill, Trans. Conn. Acad, Vol. IV., Pl. XXV. Fig. 10.)

An unknown pelagic worm (Pl. VI. Fig. 5) was found on several excursions,

tral cirrus. The final segment is destitute of lateral spines and has two long anal cirri.

The mandibles can be easily seen through the body walls, and are well developed in this early condition of the worm. The stomach extends from the second to the third or fourth body segment, and the intestine is a small straight tube. The body is transparent, colorless, or of a slight green or brownish tinge.

Pilidium recurvatum sp. nov.*

Plate V.

One of the most interesting of the worm larvæ found at Newport is a *Pilidium* which has many structural relationships to *Tornaria*, the larva of *Balanoglossus*, and to *Actinotrocha*, the young of *Phronis*. This *Pilidium* is the nurse of a worm which has many resemblances to the Nemertean genus *Lineus*. As it differs widely from any known species of *Pilidium*, I have given it for convenience in description the provisional name of *P. recurvatum* on account of the characteristic curvature at its upper end. The new *Pilidium* from Newport differs very greatly from any known species of this genus. The upper hemisphere of the larva is not greatly unlike that of the other species of the genus *Pilidium*, but the outlines of the lower hemisphere are so very exceptional that it is almost impossible to homologize it with any known forms. *P. recurvatum* has not the two circular lappets of *P. gyrans*, nor the arm-like bodies of *P. brachiatum* and *P. auriculatum*. The ring of cilia about the lower hemisphere of *P. recurvatum* is not represented in any other species of *Pilidium*, unless we homologize it with a part of the ring of large cilia on the rim of the body and along the edges of the circular oral plates of *P. gyrans*.

The youngest form of *P. recurvatum* which was taken is represented in Plate V. Fig. 1. The body is elongated, egg-shaped, with the upper end recurved and the mouth downward. The walls are of glass-clear transparency,

but always in the same condition, so that it is impossible to tell its age, although it seems to be immature. This worm is of very dark brown or black color, especially in the anterior body segments. The head is small and of spherical shape, although totally destitute of appendages. The eyes are large rounded bodies, two in number, deeply sunken into the anterior dorsal cephalic walls. They have a brownish or chocolate color.

The first six (?) anterior body segments have a black color, and bear small permanent setæ. The following segments of the body are furnished with very long spines, which are very conspicuous as the worm swims in the water. The posterior body segments resemble the anterior in bearing very short spines, although their color is lighter brown and contains more yellow than those of the middle body region. There are in all over fifty body segments. One or two specimens of this worm are taken each year, generally by night fishing.

* This nomenclature is provisional. The larva is not a true *Pilidium*.

and their outer surface is ciliated. The lower hemisphere at a short distance from the lower pole is girt about by a ring of large cilia, which by their constant movement impart onward and various rotary motions to the embryo. It sometimes moves forward in the line of its length, and then whirls on its axis without any direct forward motion. Both of these movements are the results of ciliary action. From the thin outer wall to the cavity* within extend many muscular fibres, which are sometimes simple and sometimes compound, and are generally disconnected with each other. Two of these muscular threads are more prominent than the rest, and extend from a thickening at the apex of the larva to the junction of the œsophagus and stomach. These are regarded as homologous to those muscular strings in *P. gyrans*, which were long ago noticed by J. Müller, and regarded by him, and later by Metschnikoff, as nervous elements.

From the apical thickening of the walls of the larva there arises a short, flexible flagellum, which waves back and forth as the larva moves through the water. The interior of the larva is occupied by an œsophagus, and an amniotic cavity which contains a growing Nemertine worm. The œsophagus fills almost the whole of the bent portion of the larva under the apex. It opens externally by a mouth with ciliated lips. Internally it is continued into the intestinal cavity of the Nemertean. Its walls are muscular, ciliated internally, and contractile. The external lips are slightly pigmented. No intestine or anal opening was seen in the larva. The interior of the body, from the inner end of the œsophagus to the walls which form the lower pole below the ring of cilia, is taken up by a sac, which has been homologized with the amnion of *P. gyrans*. In this sac is formed the young worm. The most conspicuous regions of the amnion are the upper, which is a prolongation toward the apex from the vicinity of the inner terminus of the œsophagus, and the lower part, near the anal pole, which occupies most of the body of the larva. Both of these regions have the walls of the amnion thickly pigmented, as shown in the figures. In the blind sac which constitutes the upper of these pigmented regions lies the future proboscis of the worm. This last structure is movable in the pigmented sheath in which it lies. It sometimes completely fills its sac, and when withdrawn leaves the pigmented amnion in the shrunken condition shown in the figure. The pigmented regions are composed of small granules of a dark red color closely crowded together. They are represented in Bütschli's figure † of *P. gyrans* by a single large and irregular pigment spot. This amniotic pigmentation is not the same as the colored bodies described by

* An *Amnion* such as has been described in *P. gyrans* is already formed in the youngest larva of *P. recurvatum* which was taken.

† In the young of *Polygordius* (Loven's larva), we have described around the margin of the disk a number of problematical bodies, which are very similar to those spoken of by several authors as existing on the rim of *Pilidium*. In both genera they may be foreign bodies, and not patterns of pigmentation. In some specimens of a large undescribed *Pilidium*, found at Newport, they were present; in others, apparently of the same species, absent.

several authors about the rim of the disk and the margin of the oral lappets in the same species.*

Two different sides may be distinguished in the larva. These may arbitrarily be known as the dorsal and ventral. The term dorsal as here used refers to the flexure of the body diametrically opposite that on which the drooping mouth hangs, while the mouth may be regarded as opening on the ventral side. In the imprisoned Nemertean there is also a corresponding dorsal and ventral side. The worm is fastened to the larval nurse by the ventral region, and is free from the amnion at all other points. It hangs in the amniotic cavity in such a manner that its ventral side lies in the same direction as the ventral side of the larva, and the proboscis extends into the recurved portion and lies in an extension of the amnion above the œsophagus. The posterior end of the body of the Nemertean in older stages of its growth is bent at right angles to its length, the extremity being bent upward on the ventral side.

Fig. 2 represents the youngest larva of *P. recurvatum* as seen from the dorsal side. The proboscis is so drawn back that it does not inflate the upper pigmented region of the amnion. The recurved outline of the upper part is turned away from the observer. The lower portion of the body is short and thick. The diameter from one side to the other is less than that measured dorso-ventrally. The general shape of the larva from this side is pyriform. One of the most prominent organs in the structure of the Nemertean enclosed in the *Pilidium* is a pair of spherical organs (*c s*), shown in both Figs. 1 and 2, just below the origin of the proboscis at its point of differentiation from the body of the worm. These bodies lie one on each side of a dorsal median line, and have lateral openings into the amniotic cavity in which the worm is contained, and are ciliated. They may be known as the cephalic sacs, and are probably the same as the "Saugnäpfe" mentioned by J. Müller. These organs are among the earliest structures to differentiate themselves in the growth of the worm, and in older stages of growth each opens externally on the sides of the head by a small ciliated orifice. Four of these bodies were mentioned by Müller, and Bütschli speaks of and figures four in *P. gyrans*. Two only were seen in this stage of *P. recurvatum*. Another pair is of later growth. In the stages of growth older than Figs. 1, 2, the external shape of the larva is somewhat changed, but the increase in size of the Nemertean contained in and borne about by the free swimming nurse takes place without any changes of great importance in the external contour of the larva.

A larva of *P. recurvatum* slightly older than that represented in Fig. 1 carries its snout in a very exceptional manner. In this larva that extremity of the body which is in the majority of cases simply dependent is carried projected outward at right angles to the longer axis of the body. This mode of extending the mouth was observed in a single specimen, and may have been an individual peculiarity. It shows, however, the capabilities of movement which the snout has.

The proboscis of a worm shown in Fig. 3 is very movable in the sac of the

* Arch. f. Naturges., 1873, Band I.

amnion in which it lies. It is here represented as filling the whole sheath, although it seldom remains long in this state, but is drawn back and forth as if even at this early stage in its career its larval life was soon to terminate. The walls of the cavity of the proboscis are well seen in a larva of the age shown in Fig. 2, especially when it is extended so as to fill its amniotic sac. Fig. 4 is another larva of about the same age as that represented in Fig. 3, which carries its snout turned down as in the majority of specimens captured. Fig. 5 is slightly older than Fig. 4, and is a view of the last from the dorsal side. It has at the lower pole a short flagellum, smaller than that found at the apex of the larva, but prominently larger than the majority of vibratile cilia with which the whole external surface of the larval body is covered.

Figs. 6, 7, 8, represent stages in the development of the worm which show a progressive growth of the contained Nemertean. It will be noticed that the whole larva has considerably lengthened its body and become slighter, while the pigmented sac which encloses the proboscis has become much larger. It is also to be noticed that the projecting snout upon which the mouth of the nurse is situated has become contracted in size, and that, as shown in Fig. 7, it has dwindled to a slight prominence. The œsophagus also keeps pace with this reduction in size of the projection in the cavity of which it lies.

In Fig. 9 the relative size of the "nurse" and the contained Nemertean is very different from that shown in previous figures. The proboscis now forms a large and prominent body in a pigmented amniotic sac, filling most of the upper portion of the larva. It moves back and forth in a most restless manner within its prison walls, and seems attempting to escape. The muscular threads which formerly united the apex of the larva with the cavity have disappeared. The lower end of the worm has grown so long that it is folded upward on the ventral side of the nurse, reaching a short distance above the region of the larva in which the ring of cilia lies. The whole of the amnion in which the posterior end of the worm lies is pigmented a fine dark red color similar to that upon the proboscis. On the ventral side of the Nemertean there is an enlargement which is the unabsorbed part of the contents of the amnion transmitted from younger conditions of growth. The walls of the amnion fit tightly upon the worm within, but in places they can be very easily distinguished from those of the worm. The cephalic sac is well marked, the cavity of the proboscis clearly evident, and a well-marked organ on the dorsal side of the Nemertean is probably the primitive formation of the dorsal water-tubes.

In Fig. 10 is represented the oldest *Pilidium* which we have observed. The contained worm has outgrown its narrow confinement, and there remains one important change by which it can extricate itself. If in order to hasten on this change, somewhat akin to evisceration, the larva be put in a small quantity of water, as in a watch crystal, the worm thus confined will be observed to move in the amniotic cavity even more briskly than before, and to fret more strongly against the barrier which envelops it. This hastens on the "critical

stage," similar in some respects to a metamorphosis which has been described in some Gephyrean worms. The enclosed Nemertean, drawing back its proboscis out of the pigmented sheath, protrudes it outside the body walls through an orifice at the lower end of the larva. In a single specimen (Fig. 15) in which the "critical stage" was observed, this opening was seen below the ring of cilia on the lower end of the larva. After resting a moment, suddenly, either normally or abnormally, the half-protruded proboscis is forced still farther outside the larva, turning the *Pilidium* in such a way that it is everted, and appears as a shrunken remnant, forming a marked enlargement at the posterior end of the body. No part of the "nurse" is unabsorbed, and even the pigmented regions of the amnion described above can be detected in the enlargement which characterizes the posterior extremity of a Nemertean which has just passed through the critical stage. In other species of *Pilidium* a majority of authors declare that the original larva, with its enclosed amnion, lives independently for some time after the escape of its Nemertean. Such is not the case in a single specimen of *P. recurvatum*, which was made to pass through the critical stage in the way described above. The body of the larva with the amnion is here absorbed into the posterior end of the body of a growing worm, which it carried in a way not unlike that in which the pluteus bears the young Sea-urchin. The absorption of the larval envelope in *Pilidium recurvatum* is in reality a true Echinoderm feature, and seems to me one more characteristic pointing to the close affinities of these worms and the Echinoderms.

The form of the worm, after it has passed through the wonderful metamorphosis which has just been described, is shown in Figs. 11 and 12. It is now no longer free-swimming, as formerly, and, although ciliated over its whole exterior, is slow moving, and immediately sinks to the bottom of the aquarium in which it is confined. The worm just after the metamorphosis from the *Pilidium* is elongated in shape, pointed at the anterior, and swollen almost globular at the posterior extremity. It is ciliated on its whole external surface. The body is semitransparent, and large patches of pigment appear in the enlargement at the posterior end of the body. Cephalic sacs, with ciliated linings, are well marked, but no eye-spots are seen on the head of the Nemertean immediately after its escape from the *Pilidium*. According to Bütschli the fully grown *Nemertes* of *P. gyrans* is probably destitute of ocelli. In the few specimens of *P. recurvatum* which were found at Newport, no ocelli were observed, while the worm was contained in the amnion previous to the critical stage, and it was only later that the two eye-spots were formed. The oldest form which we have obtained of the Nemertean derived from *P. recurvatum* is yet a long distance structurally speaking from the adult, but yet has so many resemblances to *Lineus* that I have referred it provisionally to this genus. Its general appearance from the dorsal side is shown in Fig. 14.

Many prominent differences between this and the last stages which have been described are found in the general outlines of the body. The great enlargement at the posterior extremity of the worm just escaped from the larva,

as shown in Figs. 11, 12, and 13, has become reduced in size, so that now the greatest diameter is found just behind the cephalic sacs, and the body tapers from this point backward to its posterior end. The larva has three pigmented regions, viz. the very anterior end of the snout, the region just behind the cephalic sacs, and the posterior end of the body. The eye-spots are found on the sides of the head just in advance of the cephalic sacs. These last-mentioned organs are relatively smaller than formerly, and are ciliated in their interior and on the inner walls of the tubes which lead to them from the external orifices.

The internal organs differ slightly from those of the adult *Lineus.* A large stomach, the movements in the walls of which could be easily seen, fills most of the interior of the larva. There is in this larva no visible anus. The sinuous tube (*w t*) which lies on the dorsal side of the stomach has been identified as a water vessel. A similar organ is figured by Leuckart and Pagenstecher in *P. gyrans.*

The form of this singular larva and the strange development of the enclosed worm suggest very interesting theoretical questions. The external outlines of the larva ally it to animals widely separated in our classification from the Nemertean to which it gives origin. Busch, Leuckart and Pagenstecher, and others, have pointed out that in the similar relationship of *Nemertes* to its *Pilidium* we have a parallel condition to that which exists between an *Echinus* and its *pluteus.* In the species of *Pilidium* which they studied, not only the stomach of the larva, but also its œsophagus and mouth, were found to be directly changed into the same organs in the contained Nemertean. In *P. recurvatum* the resemblance which they suggested is even closer than in those species which they have studied, for here not only is the larval mouth and œsophagus only indirectly if at all changed into the same organ in the adult, but also the lower portion of the embryo has a true brachiolarian form which is highly suggestive. Our larva, even more than those of other species of *Pilidium*, shares with *Tornaria* and *Actinotrocha* many Echinoderm characteristics.

The history of the opinions which have been advanced by Müller, Busch, Leuckart and Pagenstecher, Huxley, A. Agassiz, and others, in relation to the resemblance or want of likeness of *Tornaria* to the young Echinoderms, is too well known to be repeated here. If *Balanoglossus* were the only worm whose larva resembles the young Holothurian, the fact might be explained by the abnormal character of the adult. With the Nemerteans, however, the case is somewhat different, for in them we have a large group, whose larvæ have many points of resemblance to the embryonic Echinoderm. Nowhere is that likeness carried so far as in the strange *Pilidium recurvatum*, which has been described above. It would seem at first sight that the circular belt of cilia described in this larva would be an argument against its close affinity with the larval Echinoderm. The same thing may be said of this, which has already been said of a similar belt in *Tornaria.* Far from being an unknown feature, it is a peculiarity in some Echinoderm young, as in *Comatula* and the Holothurians, which are the closest allies of the worms. We find in some young

Holothurians the body girt by several parallel belts of cilia. One only of these rings of large cilia remains unchanged in *Tornaria* and in *Pilidium recurvatum*; but in the former genus two others, very much modified in position and never parallel, form the loop-like bands between which the mouth opens. These bands, quite simple, as I shall later show in the young *Tornaria*, have a very tortuous course later in their career, but never attain the complexity which marks the course of homologous bands on the young of our common Starfish or Sea-urchin. Much greater than its resemblance to the young Echinoderm is the likeness of our new *Pilidium* to the well-known *Tornaria*.

On the same plate with my figures of the larvæ of *P. recurvatum* are introduced for a comparison two illustrations of very young stages in the growth of *Tornaria* (*Balanoglossus*). These are still younger than any larvæ which are yet known of our American *Tornaria*, and present many very interesting features. The closeness of the relationship between them and the younger members of the series of *Pilidium* which they accompany is not the least interesting of the many comparisons which they suggest.

In the youngest (Fig. 16) we have a *Tornaria* of an irregular pear-shaped form, with well-marked œsophagus, stomach, and intestine. A mouth opens on one side of the body and an anus is found at its lower pole. The external surface of the body is crossed by two simple ciliated bands. These have a common union at the upper pole of the larva, but a very divergent course on its external surface. The shorter of these ciliated bands forms a loop varying slightly from the form of a ring, which extends from the upper pole nearly to the equator, but never into the lower hemisphere. The larger band has a more tortuous course than the other, which it resembles in its loop-like form. It is much longer, and extends into the lower hemisphere almost to the lower pole. It meets in its course the smaller band only at one point, which is at the upper pole of the embryo. The mouth opening of the young *Tornaria* lies on its equator under the eaves of a projecting upper hemisphere, and between these two ciliated bands. At the common junction of the two ciliated bands is found a pair of eye-spots, above which rises a small tuft of cilia. The *Tornaria* swims with this region uppermost in the water. From that part of the larva upon which these ocelli are borne, extending internally to the neighborhood of the union of œsophagus and stomach, passes a muscular thread very similar to like threads already mentioned in *Pilidium*. An unpaired tube extends from the point of union of the œsophagus and stomach, on its dorsal side, to the middle of the dorsal flexure, opening externally by a "dorsal pore" about diametrically opposite the mouth. The sac or enlargement of this tube at its inner terminus has not yet reached any great size.

In this youngest *Tornaria* there are, as appears also in Müller's original description of *Tornaria*, *no ring of large cilia* near the anal pole and *no lateral bodies* ("lateral plates," "lappets," A. Agassiz) by the side of the stomach, such as we find in the older *Tornariæ*. All theoretical questions which consider a comparison of these last bodies to the water-tubes of the Starfish larvæ must take cognizance of the fact that the median water-tube, which

passes to the dorsal flexure from the internal end of the œsophagus, is fully formed before any trace of the anal ring of cilia or the lateral bodies ("lappets") found near the stomach have appeared.

The second of the two figures of *Tornaria* (Fig. 17) is taken from a larva still older than the last, from which it differs in one or two particulars. The most important character which has been acquired in the growth of the former is a belt of cilia not far removed from the anal pole, which is found in all later stages in the development of the worm up to its metamorphosis into *Balanoglossus.* The same ciliated belt we also find in the larva *P. recurvatum*, the young of the Nemertean worm which we have studied, but it does not exist in the known species of *Pilidium*, which are the nearest allies of our new Nemertean larva. It is, however, represented in *Actinotrocha.*

A noticeable fact is that the lateral bodies found near the stomach in older *Tornariæ* have also not yet appeared in the growth of the internal organs at this stage of development.

There is another difference between the second and the first of these two larval youngest stages of *Tornaria.* On either side of the œsophagus, originating from the inner end of the muscular thread which arises from the eye-spots at the apex of the larva, is found a pair of rein-like bodies in the form of threads, which extend to points on either side of the mouth. It is not known what their function is, but their position is the same as that of like threads which have been described elsewhere in this paper, for the first time, in our common Loven's larva, similar to its European representative, referred by Schneider and Hatschek to the strange genus *Polygordius.* There is also another characteristic in the very young Loven's larva never yet observed by others, which seems to me of some importance in theoretical questions concerning the affinities of *Polygordius.* A very young Loven's larva was found, in which a long vibratile cilium is borne upon the apex, just as has been mentioned in *Pilidium* and the larva of the above-described Nemertean. Moreover, this cilium, which has the character of a flagellum as far as size goes, rises from a specialized portion of the body of the larva upon which eye-spots are borne. The flagellum in Loven's larva is an embryonic structure, and the portion of the larva which carries it is directly changed into the head of the future worm. In the Nemerteans, however, the flagellum is embryonic, like that of Loven's larva, but the body of the larva plays no part in the formation of the head of the worm, but by its wonderful metamorphosis makes the whole posterior extremity of the larva. No *Tornaria* has been observed with this flagellum at its apex, unless we homologize with it a small tuft of cilia larger than the others on the surface of the body, found at the apex of our youngest larva. Close as the resemblances between *Tornaria* and *Pilidium recurvatum* are, there are many very intimate relationships between the latter and the young of the Gephyrean worm *Phoronis* when known as *Actinotrocha.* The rapidity of the transformation of the *Pilidium* into the Nemertean, more especially the apparent evisceration and turning inside out of the larva at that time, led me at first to regard my larva as the young of some unknown worm allied to

Phoronis. Indeed, I have borrowed from those who have written on the metamorphosis of *Actinotrocha* the term "critical stage," on account of this likeness. I have no hesitation now in identifying *Pilidium recurvatum* as a young Nemertean, rather than a young Gephyrean, although I am doubtful whether I know the generic name of its parent.

Prominent among the characteristics which *Pilidium recurvatum* shares with *Actinotrocha* is the existence in both of a belt of cilia which divides the body into such unequal parts. These regions thus marked out resemble each other in general shape, and probably, if a younger larva of *Pilidium* could be compared with those already known of *Actinotrocha,* before the arms had formed, even closer resemblances might be traced between them. Whatever likenesses there are earlier in the internal organs, they have now been completely masked by the progress of the development. It is very difficult to compare the youngest known *Pilidium recurvatum* with *Actinotrocha,* as far as the internal organs are concerned, notwithstanding there is such a similarity in external outlines.

Polygordius ("Loven's Larva").

Plate II.

The writings of A. Agassiz, Schneider, and Hatschek,* on the development of the very common larva known as Loven's larva, have given a history of its metamorphosis from a somewhat advanced larva into the adult form. All is still dark, however, in regard to the segmentation of the egg and the earliest forms which the larva passes through. As any contribution to either of these parts of the subject must have a value, figures and descriptions of two larvæ younger than any of this worm yet described are here introduced. These take us one step nearer a complete knowledge of the growth and early history of this most interesting worm.

Loven's larvæ are among the most common Annelid larvæ taken in the dip-net at Newport. They are found in all conditions and of all sizes, sometimes swarming in numbers in the collecting glasses. The youngest larva which was found, Fig. 10, has a general structure as follows.

The body of the larva is spherical, transparent, and as gelatinous as that of a Medusa. In its movements in the water it tumbles about, moved principally by the strokes upon the water of an equatorially placed double belt of cilia. The larva has a slightly irregular spherical form, rounded above, somewhat flattened below, and girt midway by two † rings of motor cilia. The hemisphere above these ciliated bands may be called the upper hemisphere, and that below the lower. The upper hemisphere is, with the exception of a slight prominence on one side, regularly rounded and dome-shaped ; the lower is flattened,

* According to the last-mentioned authors, Loven's larva is the young of the strange genus *Polygordius.*

† See Balfour, Treatise on Comparative Embryology. Our *Polygordius* larva is like the European in having two ciliated belts.

broken by an eccentric protuberance on one side. Both mouth and anus open through the lower hemisphere ; the former on one side just below the upper of the equatorial ciliated bands, and the latter on the eccentric prominence already mentioned. The whole exterior surface of the body is ciliated, and the equatorial band consists of two parallel rings, which extend side by side for most of their course, and separate from each other in the region of the mouth, the larger passing above and the smaller below this orifice. This position of the two ciliated rings in an older larva can be seen in Loven's original figures of the European larva. The upper hemisphere has its walls unbroken by any orifice, and is of regular dome-like shape. At its pole arises a short flagellum (*f*), which waves back and forth as the larva moves through the water. The flagellum found at its apex is an embryonic structure, and appears to be lost in more advanced larvæ. On the body walls just below the pole, in a granular zone surrounding the point from which the flagellum arises, there is a collection of cells more or less scattered, the thickness of which decreases more and more near the ciliated equatorial band. This granular mass is the first appearance of that nervous centre which later aggregates about this pole of the larva, and bears the ocelli. Slightly removed from the base of the flagellum, in the walls of the larva, are two pigment spots, one on each side, with well-marked lens, which as the larva grows older and older approximate closer and closer, until they are brought into the immediate vicinity of the pole, in connection with the consolidated collection of cells already mentioned. In the youngest larva, however, they are widely separated ; later, they grow nearer each other. Two prominent clusters of cells (*c d*) are found in the lower hemisphere in the walls diametrically opposite the cluster on the upper hemisphere. These also later form a nervous centre at this extremity of the worm. Around the rim of the larva, in the slight ring-shaped protuberance from which the cilia arise, many brown and yellow colored cellular bodies (Fig. 10^a, *p*) of a problematical character can be found. These bodies vary somewhat in color and size, being generally brownish, yellowish, or greenish, and have a regular spherical shape. They appear to be suspended in membranous dilatations of the disk rim, and to hang from it by a slight attachment. Their disposition on the bell margin is irregular, and not constant. Can this be an instance of the symbiosis of an algous growth on a worm larva?

The interior of the larva is occupied for the most part by three cavities, each with its own walls separate from those of the body cavity. Two of these have external openings into the medium in which the larva lives. The greater part of the interior of the larva is occupied by the largest of these three organs, which is called the stomach. This structure, which is almost globular in shape, has two openings, one into each of the two smaller cavities. It does not communicate with the surrounding water, and its whole inner surface is ciliated. Of the remaining two internal sacs, one is an œsophagus, and the other an intestine. The œsophagus opens externally through the mouth, and internally into the stomach. Its walls are muscular, contractile, and the inner surface is ciliated. Granules of food in masses were observed in its cavity.

The intestine is more globular in shape than the œsophagus, opening internally into the stomach, and externally through the anus. Its inner walls are ciliated, and its cavity is partially filled in many specimens with fæces.

In a second slightly older larva (Fig. 11) of *Polygordius*, several additions in structure have been made, and marked modifications in form have taken place. In the general outline, the most important change is the flattening of the whole larva, especially on the lower hemisphere, by which the equatorial axis is relatively very much increased. The flagellum on the apex of the upper hemisphere has disappeared, and the two ocelli have drawn still more closely together; so that both now lie very close to the apical pole. The stomach has become more elongated in shape, while the œsophagus has assumed a more tubular form. The beginnings of the funnel-shaped bodies described by Hatschek in the European Loven's larva can be seen as two globular sacs (*e*), one on each side of the stomach, on a level just above a plane passing through the equatorial ring of cilia. Two prominent fibres arise from the collection of cells upon which the ocelli are placed, and pass to the lips above the mouth. Two other threads have a similar origin, and extend meridionally on each side of the stomach to the clusters of cells on the inner walls of the lower hemisphere, at the anal pole of the body. A third pair of threads, hitherto unnoticed, take their rise from the same clusters of cells at the anal pole, and extend parallel with each other to the lower lips of the mouth. They end near two pigment bodies which are constantly found in this region.

The different larval stages in the development of Loven's larva which lie between that represented in Fig. 11 and the adult Fig. 18 have been figured by Hatschek for the European species, and for the American representative by A. Agassiz. New figures of the American larva are introduced in order to show the peculiar brown bodies found about the bell margin, which seem to be characteristic, and the two ventral "nerve cords" shown in Fig. 14, *v n*, which are unrepresented in any drawings of these larvæ which have been published. With the exception of these two differences, our common Loven's larva is similar to the European.

Capitella (young).

A larva referred to the genus *Capitella* has been taken several times in our Newport fishing. These were always in the same condition as that figured in Plate III. Figs. 19, 20, and do not differ essentially from one already represented by Claparède and Metschnikoff.*

Lumbriconereis.

Plate VII.

The cove near the laboratory is the home of many genera of Annelides which live in the fine mud covering the bottom in many places. In the months of June, July, and August, a plentiful supply of eggs in all stages of growth,

* *Op. cit.*

which were identified as belonging to the genus *Lumbriconereis*, were collected at low tide from this locality. They were found attached to the surface of the mud in the form of gelatinous clusters glued together in spherical masses of slime, which, when the flats are covered with water, wave to and fro with passing currents. In size and general external appearance, they closely resemble similar clusters of mollusk eggs found in the same place. The worm embryos, however, have a more greenish color than that of the mollusk, and can after a little practice be distinguished by the unaided eye.

The segmentation of the *Arenicola* egg, which is identical with that of *Lumbriconereis*, has been described and figured by several naturalists, so that the changes which take place in the egg up to the formation of the planula are well known. The series of larval forms which are described and figured in this paper opens with one where a segmentation of the ovum is completed, and extends to a larva in which certain generic structures of *Lumbriconereis* are well marked.*

In Fig. 1 we have represented the egg at that period in its development when the smaller spheres, "micromeres," have partially grown about the larger "macromeres," two of which seen in profile appear at one pole. When the pole at which the macromeres lie is seen from above, so that they occupy the centre of the circle of vision, four macromeres surrounded by the encroaching micromeres can be easily seen. When viewed in profile, as in the figures given, only two of the larger spheres appear. In an egg a little older, the forming micromeres encroach still more on the pole at which the macromeres approach the surface of the ovum, until ultimately the latter are wholly surrounded by the smaller cells.

The youngest of the planula series has a spherical and slightly ovate form, bearing at one pole a clear projection easily distinguishable from the remaining parts of the embryo. This projection may be called a cephalic prominence. The whole interior of the larva is occupied by large nucleated cells, which are easily seen through a transparent outer layer. On the pole opposite that capped by the transparent cephalic projection which has been mentioned, there has been differentiated from the outer surface a thin layer which marks the beginning of the body of the worm. The cap-shaped cephalic prominence at the upper pole is the first appearance of a head. The whole external surface which lies between these prominences of the larval body is a broad ciliated zone, which occupies the greater part of the external surface of the worm.

The first important additions to a simple larva girt by a broad band of cilia, which we have just described, is the formation, at either pole, in the clear spaces which we have mentioned, of small prominent pigment spots. Five of these are formed at the cephalic, and four at the caudal pole. Those which appear in the cephalic prominence are three in number, placed one medially, with one on each side near the pole, and one on each side near the equatorial

* These larvæ resemble closely the young *Arenicola marina* (*piscatorum*) of Max Schultze (Abhand. d. Natur. Gesell., 1856), or those of *A. cristata*, Stimp., described by Dr. E. B. Wilson, *op. cit.* The larvæ doubtfully referred to *Lumbriconereis* by Claparède and Metschnikoff (*op. cit.*) are generically different from mine.

band of cilia. The caudal embryonic spots are arranged in a row side by side, near the lower or caudal pole. From each pigment spot, cephalic or caudal, pass towards the centre of the larva a number of delicate threads, which are ultimately lost in the larval body. The cephalic protuberance is formed of two layers, an outer transparent, and an inner more opaque. The large cells, macromeres, in the interior of the larva, are smaller in number, and do not occupy as large a part of the embryo as formerly. The ciliated band has narrowed relatively to the length of the whole embryo.

Fig. 4 is taken from a larva still older than the last. In this embryo, the cephalic protuberance has been but little changed, while the caudal has grown much larger than formerly. The most important additions in this embryo are two rows of lateral pigment spots on the posterior margin of the ciliated band. These lateral spots persist into very late stages in the growth of the worm, and are identical with those collections of pigment found on the auricles which bear embryonic cephalic spines in *Nerine*, *Spio*, and other genera. The row of lateral ocelli (?) cross the body of the embryo following the lower edge of the ciliated band in an oblique direction. Around the dorsal surface of the larva the ciliated band is uniform in breadth, but on the opposite or ventral side it contracts and narrows to fully two thirds its former width. The oblique direction of the lateral lines of pigment is due to this narrowing of the ciliated band. Posterior to the narrowest part of the ciliated band is a clear space, into which, on the ventral side, the mouth opens.

The posterior or caudal portion, which is in reality the growing body of the worm, now becomes more elongated, and the two layers which form its walls become more and more evident. The central part is not yet differentiated into stomach and intestine, but is made up of large and small clusters of original macromere cells.

In Fig. 7 is seen the formation of the first body segment with its solitary spine. The head is now more pointed than formerly, and through its walls, near the upper margin of the ciliated band on the ventral side, two small clusters of cells, the origin of the infraœsophageal ganglia, appear. The body has become more elongated, and is swollen midway in its course, at the points in which the first parapodia are formed. One or two more pigment spots have formed at the posterior terminus of the body.

The spines first appear as needle-like bodies, enclosed in the lateral walls midway between the posterior border of the ciliated band and the caudal pole of the embryo. It is only after they break through the walls which surround them, and greatly increase their size, that their extremity is modified in the manner shown in the figure.

In Fig. 8, a still older larva than that last described, it can be seen that the spines of the first parapodium have already broken through the external body walls, and a second segment has begun to form behind the first. As in the former only a single spine at first appears on each side, so here there forms on the second parapodium a simple spicule imbedded in the body walls. The whole worm has lengthened very considerably, and a mouth has broken through

into a clear space beneath the ventral surface, the beginning of the œsophagus. No ciliary ring has yet appeared at the anal end of the larva.

The embryo, although possessing spines which can be projected from the body, and a ring of cilia about the head, is still with others enclosed in the mass of slime in which they were laid. All have very limited movements, even when artificially set free from the cluster in which they are bound together. Their bodies, especially the central part, have a dirty green color, while the head, ciliated band, and body walls are more transparent.

In the subsequent changes which the external form of the larva passes through, there is little of interest to be mentioned. Parapodium after parapodium is added, increasing the length of the body of the worm. The new segments always arise back of that which is previously formed, while in advance of all, between the first body segment and the posterior border of the ciliated band, marked on the sides by the lateral rows of pigment spots, there are no lateral appendages to the external body walls. From its position and its subsequent history, this bare part of the body immediately behind the head is probably homologous with the anterior body region (*a r*, Fig. 1), which has been already elsewhere described in the genus *Prionospio.*

In my figure of the larval *Lumbriconereis* with two pairs of well-formed spines, it will be noticed that the digestive tract has already differentiated itself into two regions, an anterior, larger, and more capacious, and a posterior more tubular portion. The former of these is later changed into the stomach, while the latter is destined to form the intestine. The point of separation of one of these from the other is not yet well marked.

At the anterior end of the stomach, on one side, a globular body is constricted from the stomach walls at about this time. The ultimate history of this organ has not been traced, and its function is unknown. A similar body has been mentioned in the young *Nephthys.* The jaws in the larval, as in the adult *Lumbriconereis,* are very complicated, and consist of two parts, a dorsal and a ventral. The ventral jaw is formed of a single crescentic chætinous plate, the horns of which extend forward. The regularity of the concavity of the anterior edge of the jaw is broken by a single small median tooth. The posterior edge of the jaw is continued backward into two elongated projections, which extend parallel with each other, and are separated by a narrow slit.

The dorsal jaws are still more complicated than the ventral. They consist of four pairs of chætinous articulations which act as teeth, and are arranged in pairs the members of which are placed opposite each other. The two anterior of these are simple teeth with smooth edges, the former with a triangular outline ; the latter is more elongated, narrower, and more pointed.

The body of the dorsal jaws is formed of two flat or slightly curved oblong plates, whose opposite edges are serrated. By the approximation of these borders, the true function of this complicated mechanism is accomplished. To these oblong, serrated plates, on their posterior border, are articulated the last pair of bodies which form the dorsal jaws. These take a triangular shape, and have for their function a firm attachment for the remaining parts of the jaw.

They have a ligamentous junction with the posterior border of the oblong serrated plates which form the body of the jaw.

In their simplest form there is a remote resemblance between these jaws and the chætinous teeth of the species of *Branchiobdella* found parasitic on the crayfish.

Nectonema agilis Verr.

Plate VIII.

Almost every summer for a number of years we have captured at Newport a worm of doubtful affinities, which seems to be the same as that described by Prof. Verrill as *Nectonema agilis*.* The only description of *Nectonema* known to me is found in the Proc. Nat. Mus., 1879, p. 187. The present account will be found to confirm in the main the excellent observations recorded there by Prof. Verrill, and I hope add something to what little is at present known of its highly interesting anatomy. As no figures have yet appeared of this worm, a few are introduced in Plate VIII. to illustrate its general form.

Three specimens of *Nectonema* were collected in 1883. These were found free-swimming, and were taken in evening fishing.

The body is long, thread-like, round, with the lateral lines slightly flattened. It has a light brown or straw color and nearly opaque walls. *Nectonema* moves through the water with great rapidity, coiling and uncoiling itself with tireless energy as it swims. The length of the body varies in the specimens studied, from four to six inches.

The external body walls are smooth and unsegmented. Generally opaque, in some specimens internal organs can be seen through its sides. The two extremities are for the most part the most transparent.

From one extremity to the other on each side there extends a well-defined, broad, lateral band, which is laid out in squares marked in outline by black pigment. This superficial marking may define a deeper anatomical segmentation, or it may be confined to the surface of the body and the walls immediately adjacent below the surface. Each square is separated from its neighbors by a raised band. The dorsal † sides of the squares appear the most densely pigmented. A granulated line of cells extends from one end to the other through all the lateral squares which make up the lateral bands.

In some specimens there is found on the lateral bands two rows of hairs closely crowded together, so that they sometimes appear in bundles. These hairs seem to be connected by a muscular web, and are generally covered with mucus and foreign matter which has become attached to them.

Although the two extremities closely resemble each other, there exists a marked difference between them in minute anatomy.

* My attention was called to his description by Prof. Verrill, on being asked to identify one of my specimens.

† Dorsal and ventral lines of the body of this filiform worm are very difficult to distinguish.

The anterior end (Figs. 5, 6, 7, 8) is blunter than the posterior (Fig. 10), and in one specimen has a clear cavity within, easily seen through the cephalic walls, in which, as Verrill has already mentioned, four transparent, nucleated, cells lie. The mouth cannot be observed very distinctly, but is discovered by close observation on the ventral side of the head as a narrow longitudinal* slit. There are no cephalic tentacles or other appendages to the head. A pigment spot was noticed in the walls of the head just in advance of the transparent region, but whether it is an ocellus or not was not determined. The digestive tract, which is of varying diameter, but always small as compared with that of the body cavity, extends from one extremity of the crown to the other. The walls are muscular, and at times have a rhythmic pulsatile motion, which may be seen through the body walls. The anus is terminal, and mounted on a curved caudal prolongation of the body, slightly enlarged at its extremity. According to Prof. Verrill the posterior end of the male and female *Nectonema* differ from each other, and he speaks of a peculiar "papilla" found in this region of the female.

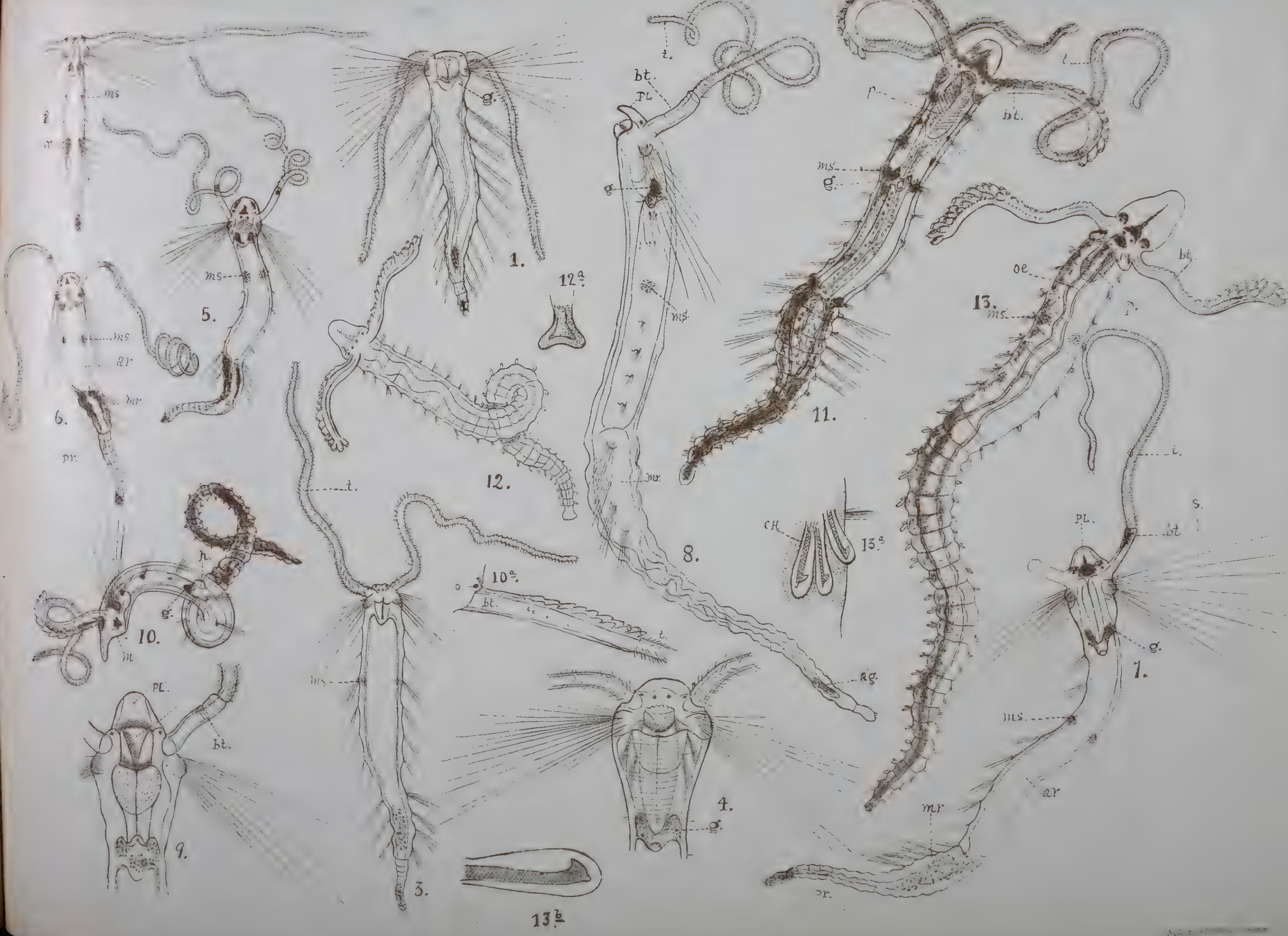
The stomach and intestine often become so inflated that they fill the body, so that they cannot be distinguished from those of the body cavity. The "yellowish white organ [ovary ?] extending from near the head to the tail," mentioned by Prof. Verrill, was observed in one specimen.

The affinities of this singular worm with known genera are somewhat doubtful. Prof. Verrill, with an implied expression of doubt, refers it to the Nematodes. That reference seems to me a proper one, but from what little is known of its anatomy it can find few near relatives among the genera now known in this group of worms. It must, if a Nematode, take its place near the *Chætosomidæ*, or perhaps by the side of that strange worm *Eubostrichus*, of even more problematical affinities, described by Greef,† from the North Sea. If near the latter, it is as a giant with a pygmy, for *Eubostrichus* is but 8 mm. in length, while *Nectonema* is ten times as large. The matted covering, formed of hairs, which characterizes *Eubostrichus* according to Greef, does not exist in *Nectonema*. There is, however, a tendency for something like this covering to form on the hairs along the lateral lines. *Nectonema* is a genus with close affinities on the one side with the Nematodes, while on the other it presents strongly marked Chætopod characters. The segmentation so pronounced on the lateral bands, and the double row of hairs upon the sides, point to the Annelides as its nearest allies. The connecting web of the lateral hairs recalls the lateral fins of *Sagitta*.

* In Prof. Verrill's specimen, "a *transverse* whitish band seemed to indicate the position of the mouth."

† Arch. f. Naturg., 1869.

CAMBRIDGE, December, 1883.



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EXPLANATION OF THE PLATES.

PLATE I.

Prionospio tenuis Verr.

a r. Anterior region of the body.
a g. Anal gland.
b t. Basal joint of the tentacle, which, as the larva grows older, increases its size at the expense of the embryonic tentacle (*t*).
c h. "Crochet hook" spines.
g. Glandular body which originates as a sac-like prolongation of the stomach cavity, becomes pigmented, and is ultimately lost in older larvæ.
h. Heart.
m. Mouth.
m s. Cluster of pigment spots found on the fourth body segment.
o. Ocellus.
p. Proboscis.
p l. Præoral lobe.
p r. Posterior region of the body.
s. Embryonic setæ.

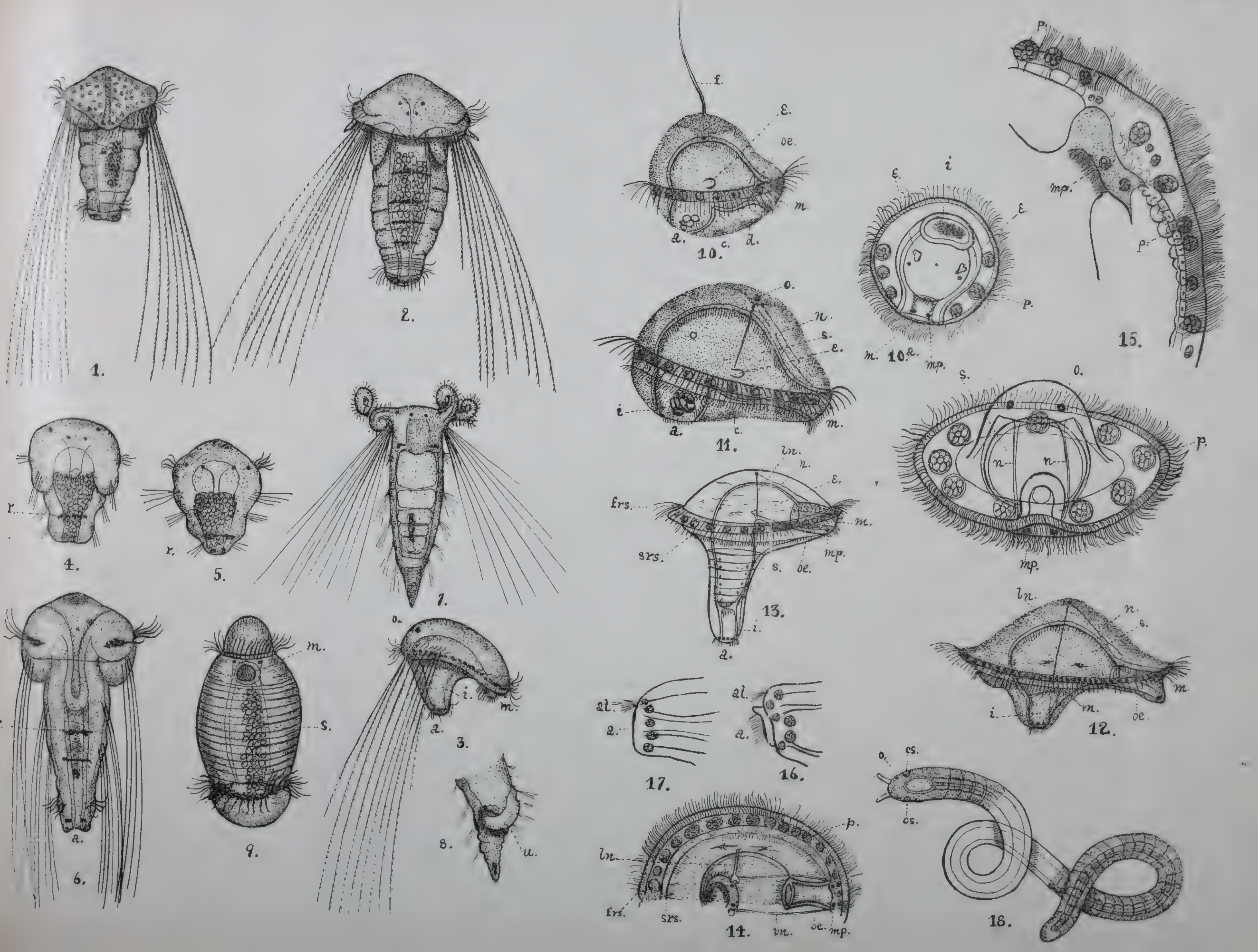
Figs. 1, 2. Young larvæ of *P. tenuis*.
" 3. Young of the same, a little more advanced in age.
" 4. Head of the last larva from the ventral side.
" 5. Still older larva in which an articulation has appeared at the base of the cephalic tentacle.
" 6. The same, with the cephalic setæ pressed to the sides of the body.
" 7. Still older larva.
" 8. Side view of the last.
" 9. Ventral view of the head of the same.
" 10. Side view of an older larva.
" 11. Older larva, in which the cephalic spines have disappeared (dorsal view).
" 12. More developed larva in which the provisional cephalic tentacles have been replaced by the permanent branchiæ.
" 12a. Posterior segment of the last larva (dorsal view).
" 13. Oldest observed larva of *P. tenuis*.
" 13a. " Crochet hook" spines of posterior segments.
" 13b. One of the same magnified.

PLATE II.

Spio, Aricidea, and Polygordius.

a. Anus.
at. Tuft of cilia arising from the caudal extremity of the body on the dorsal side of the vent.
c. Cluster of cells near the anal pole of the larva.
cs. Ciliated pits.
d. Cluster of cells which later concentrate into a cephalic ganglion.
e. Funnel-shaped organ described by Hatschek.
f. Flagellum.
frs. Larger ciliated belt.
i. Intestine.
ln. Lateral nerves.
m. Mouth.
mp. Pigmented bodies on the lower lip.
n. Nerve from apical ganglion to upper lip.
o. Ocellus.
œ. Œsophagus.
p. Spherical bodies on rim of the disk.
r. Characteristic pigment band on the dorsal region.
s. Stomach.
srs. Smaller ciliated belt.
u. Transparent projection on the dorsal side at the junction of anterior and posterior body regions.
vn. Ventral nerve, extending from the caudal end of the larva to the spherical bodies found on the lower lips.

Fig. 1. *Spio* larva (dorsal view).
" 2. More advanced larva of the same.
" 3. *Spio* larva (side view).
" 4. *Aricidea* larva (dorsal view).
" 5. The same, with embryonic spines elevated.
" 6. Older larva of *Aricidia*.
" 7. Youngest larva of *Prionospio tenuis* Verr.
" 8. Posterior region of the last.
" 9. *Capitella* larva.
" 10. Youngest "Loven's Larva" (*Polygordius*).
" 10ᵃ. The same, from above.
" 11. Still older larva of the same.
" 12. Older Loven's Larva.
" 13. More advanced larva (side view).
" 14. View of the same from above.
" 15. Magnified portion of the rim of the last.
" 16, 17. Pigmentation of posterior end of *Polygordius* larva (16, anus closed; 17, cloacal wall extruded).
" 18. Adult *Polygordius* raised from the above larva.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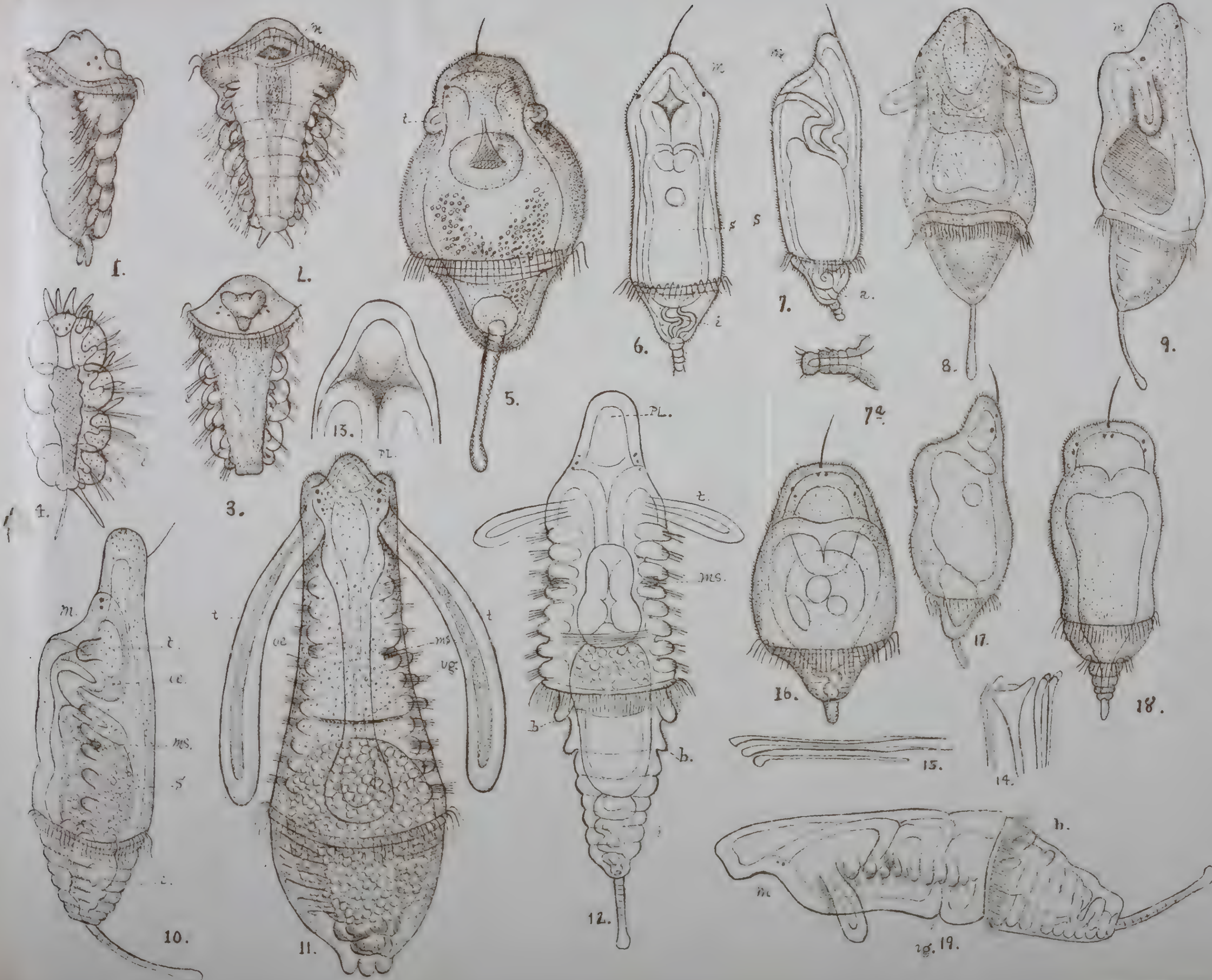
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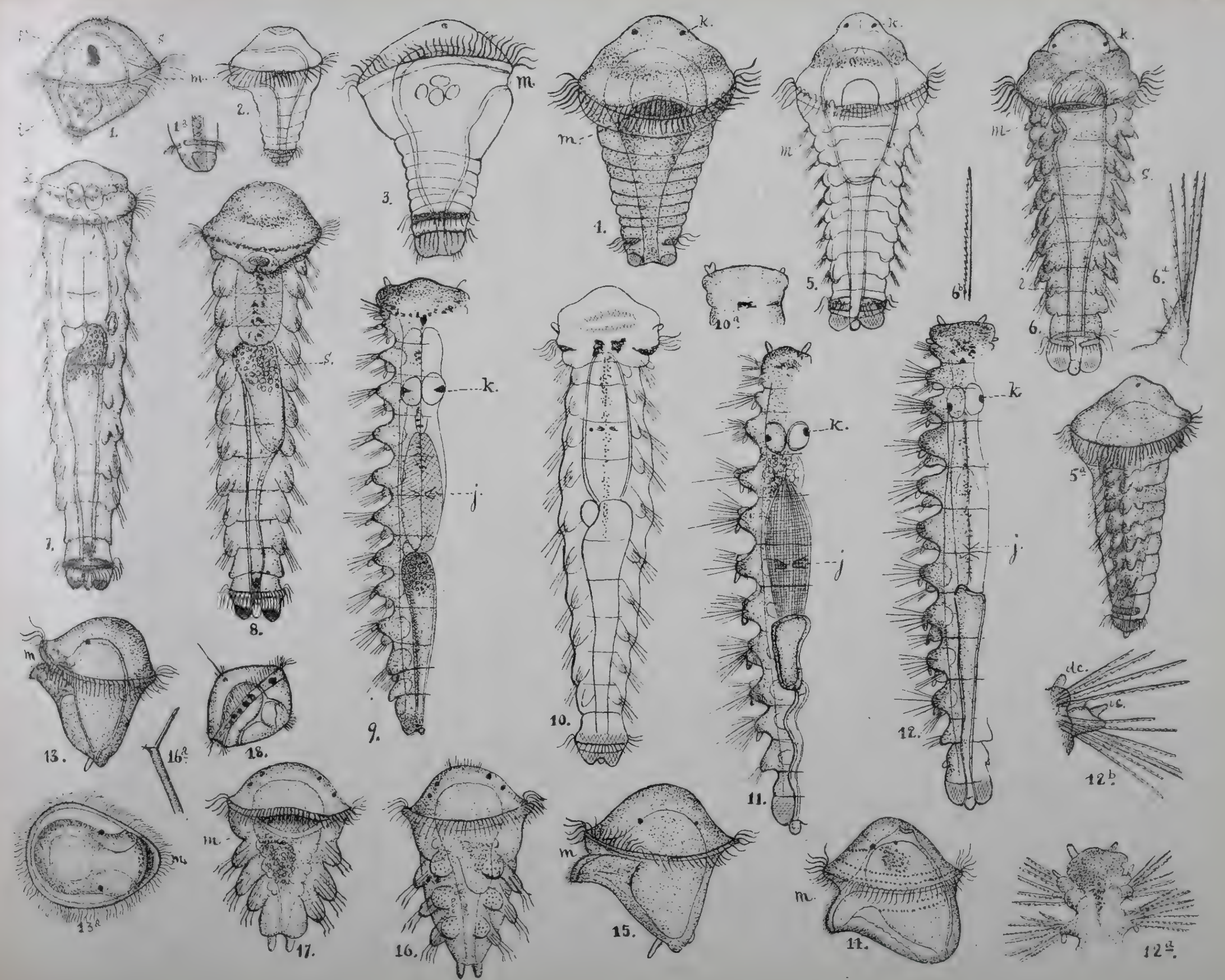

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PLATE III.

Lepidonotus, Telepsavus, and Phyllochætopterus.

a.	Anus.	*œ.*	Œsophagus.
b.	Branchiæ.	*pl.*	Præoral lobe.
e.	Elytron.	*s.*	Stomach.
i.	Intestine.	*t.*	Tentacle.
m.	Mouth.	*vg.*	Ventral gland.
ms.	Modified fourth segment.		

Fig. 1. Side view of a young larva of *Lepidonotus.*
" 2. Ventral view of a still more advanced larva of *Lepidonotus.*
" 3. Older larva of the same.
" 4. Oldest larva of *Lepidonotus* (dorsal view).
" 5–15. *Telepsavus* (?). (Figs. 8–15 drawn by A. Agassiz.)
" 5ª. Youngest larva of *Telepsavus* (dorsal view).
" 6. Older larva of *Telepsavus* (ventral view).
" 7. Side view of the last.
" 7ª. Tail of the last.
" 8. Older larva of *Telepsavus.*
" 9. Side view of the last.
" 10. Side view of a still older larva.
" 11. A larva still older (dorsal view).
" 12. Oldest *Telepsavus* larva.
" 13. Mouth and præoral lobe of the same.
" 14, 15. Differently formed spines of the oldest larva.
" 16–18. Larvæ of *Phyllochætopterus* (?).
" 16. Youngest larva of *Phyllochætopterus.*
" 17. Side view of the same.
" 18. Older larva of the same.
" 19, 20. Larvæ of *Capitella.*

PLATE IV.

Nephthys and Lepidonotus.

dc.	Dorsal cirrus.	*m.*	Mouth.
i.	Intestine.	*ps.*	Pigment spots.
j.	Jaws.	*s.*	Stomach.
k.	Cephalic spots (ocelli ?).	*vc.*	Ventral cirrus.

Fig. 1. Youngest larva of *Nephthys.*
" 2. Older larva of the same.
" 3. The same.
" 4. Still older larva from the ventral side.
" 5. Later stage (ventral view).
" 5ª. Lateral view of the last.
" 6. Larva with well-developed parapodia.
" 6ª. Single parapodium of the same.

Fig. 6[b]. Serrated spine of parapodium.
" 7. Larva of *Nephthys* older than the last. View from the dorsal side.
" 8. The same. View from the ventral side.
" 9. Larva of *Nephthys* in which the cephalic tentacles have begun to form.
" 10. The same. View from the dorsal side.
" 11. Still older larva.
" 12. Oldest larva of *Nephthys*.
" 12[a]. Head of the same.
" 12[b]. Parapodium of fourth segment.
" 13. Larva of *Harmothoë* (?).
" 13[a]. The same seen from above.
" 14. Youngest larva found of *Lepidonotus squamatus*.
" 15. The same, more advanced in growth (lateral view).
" 16. More advanced stage of *Lepidonotus* than the last (dorsal view).
" 17. The same (ventral view).
" 18. Telotrochal larva allied to the young of *Polygordius*.

PLATE V.

Pilidium (?) and Tornaria.

a. Anterior end of the worm.
c o. External opening of the cephalic sac.
c s. Cephalic sac.
d p. Dorsal pore.
i. Invagination in the lateral wall of the larva.
m. Mouth.
œ. Œsophagus.
r. Half-absorbed remnant of the larva.
s. Stomach.
w t. Water vascular system.

Fig. 1. Youngest Nemertean larva with well-developed œsophagus and stomach.
" 2. Dorsal view of the same.
" 3. Older larva with extended snout.
" 4. Larva still older than the last.
" 5. Dorsal view of the same.
" 6. Older larva with lengthened proboscis.
" 7. Larva just before the extrusion of the worm.
" 8. Larva of the same age as that shown in Fig. 3, yet without cephalic sacs.
" 9, 10. Larva just before the birth of the contained Nemertean.
" 11. Young worm just transformed from the larva.
" 12. Dorsal view of the same.
" 13. Side view of the last.
" 14. An older Nemertean which probably developed from the last.
" 14[a]. Proboscis, seen from below.
" 14[b]. The same, from one side.
" 15. Critical stage in the metamorphosis from the original larva.
" 16. Youngest *Tornaria* found at Newport.
" 17. Still more mature *Tornaria*, also from Newport.

PLATE VI.

Aricidea, Nereis, and Unknown Genera.

m. Mouth.
ms. Mandibles.
mt. Median tentacle.
œ. Œsophagus.
pr. Ring-shaped pigment regions on ventral side of body.
q. Two ventral pigment spots on fourth body [segment.
r. Dorsal pigment bands.

Fig. 1. Larva of *Aricidea* (dorsal view).
" 2. Unknown Annelid larva with two ventral pigment spots.
" 3. The same, slightly older.
" 4. The same, older (Figs. 2, 3, 4, ventral view).
" 4a. Side view of Fig. 2, showing the prominence (*g*) upon which the ventral pigment spot is borne.
" 4b. Side view of ventral prominence in Fig. 4.
" 5. Unknown pelagic worm larva.
" 6. Larva of *Nereis*.
" 6a. Head and jaws of the last.
" 7. Larval Annelid with pigmented ventral rings, described in the text as polytrochal larva (ventral view).
" 8. The same, dorsal view.
" 9. The same, lateral view (head represented downward).
" 10. Larva of *Aricidea* more advanced than that shown in Fig. 1.

PLATE VII.

Lumbriconereis.

ap. Anterior pole.
ar. Anterior body region.
cb. Ciliated band.
cp. Caudal pigment spots.
i. Intestine.
j. Jaws.
lo. Lateral ocelli.
lp. Lateral pigment spots.
m. Mouth.
ma. Macromeres.
mi. Micromeres.
nc. Ventral nerve cells.
œ. Œsophagus.
pp. Posterior pigment spots which ultimately become the caudal pigment spots, *cp.*
s. Stomach.
z. Unknown organ developed from stomach.

Fig. 1. Egg of *Lumbriconereis*, in which the micromeres have almost wholly surrounded the macromeres.
" 2. Larva of *Lumbriconereis*, in which the anterior prominence (*a p*), the ciliated band, and the external layer have formed. The large macromere cells are to be seen in the middle of the larva through its walls.
" 3. Still older larva of the same, more elongated, and with the anterior prominence pointing to one side.
" 4. Larva of *Lumbriconereis*, in which the internal large cells are less distinct, and in which cephalic and caudal ocelli have appeared.
" 5. The same larva, a little older, in which lateral pigment spots, as well as those mentioned in the preceding figure, are seen.
" 6. A larva still older, the caudal segment of which has begun to lengthen into the future body of the worm.

Fig. 7. Larva of *Lumbriconereis*, showing the formation of the mouth and first body segment (1) below the ciliated band. The two clusters of cells above the upper border of the same, near the medial line, are the beginnings of cephalic ganglia. (Ventral view.)

" 7ª. Lateral view of a larva a little younger than the last.

" 8. Larval *Lumbriconereis* older than that shown in Fig. 7.

" 9. Still more mature larva of the same, with the rudiments of a second (2) and third (3) body segment.

" 10. The same larva still more mature.

" 11. Larva with three well-defined parapodia and rudiments of two segments posterior to the last.

" 12. A more mature larva with extended setæ and well-developed jaws.

" 13. The oldest form of the larval series referred to *Lumbriconereis* possessing seven pairs of setæ, the most anterior of which are doubled, while the immature forms of new spines can be seen in the more posterior segments.

PLATE VIII.

Lumbriconereis, Nectonema, and Unknown Genus.

a. Anus.
cp. Ciliated pits on the sides of the head.
is. Immature setæ at the base of those already formed in the body walls.
l. Lateral lines.
lj. Lower jaw.
sg. Division between two segments.
uj. Upper jaw.
w. Segmental orifice.
wb. Body walls.
1, 2, 3, 4, in Fig. 3ª, articulations which together form the lower jaw. Of these No. 1 is anterior.

Fig. 1. Setæ and muscular attachments of the same in *Lumbriconereis* larva. (The spine is represented as retracted.)

" 2. The same, extended.

" 3. Larval *Lumbriconereis* with three parapodia.

" 4–10. *Nectonema agilis* Verr.

" 4. The adult *Nectonema*.

" 5. Enlarged view of the head of the same.

" 6. The head from dorsal side.

" 7. Clear space with contained cells (ova ?) in the head.

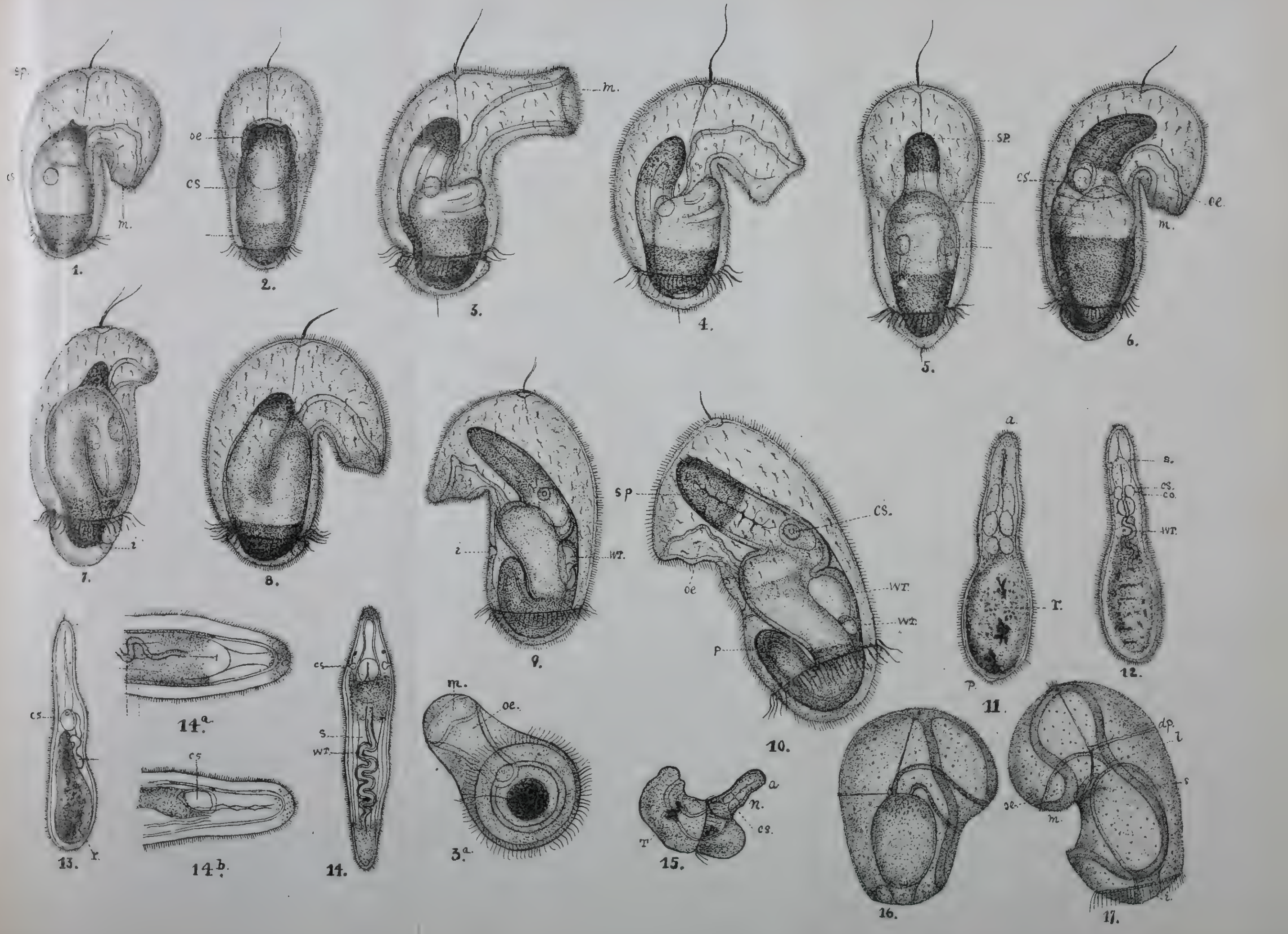
" 8. The same from dorsal side.

" 9. Magnified view of a section of the lateral line, destitute of lateral spines and "connecting web." These last structures were not found in this specimen.

" 10. Posterior end of the body (♀ ?).

" 11. *Cephalotrix linearis* (young).

" 12–14. Three larval stages in the development of a mesotrochal Annelid, probably *Telepsavus* or *Phyllochaetopterus*. (Younger than those figured in Pl. III. See text.)



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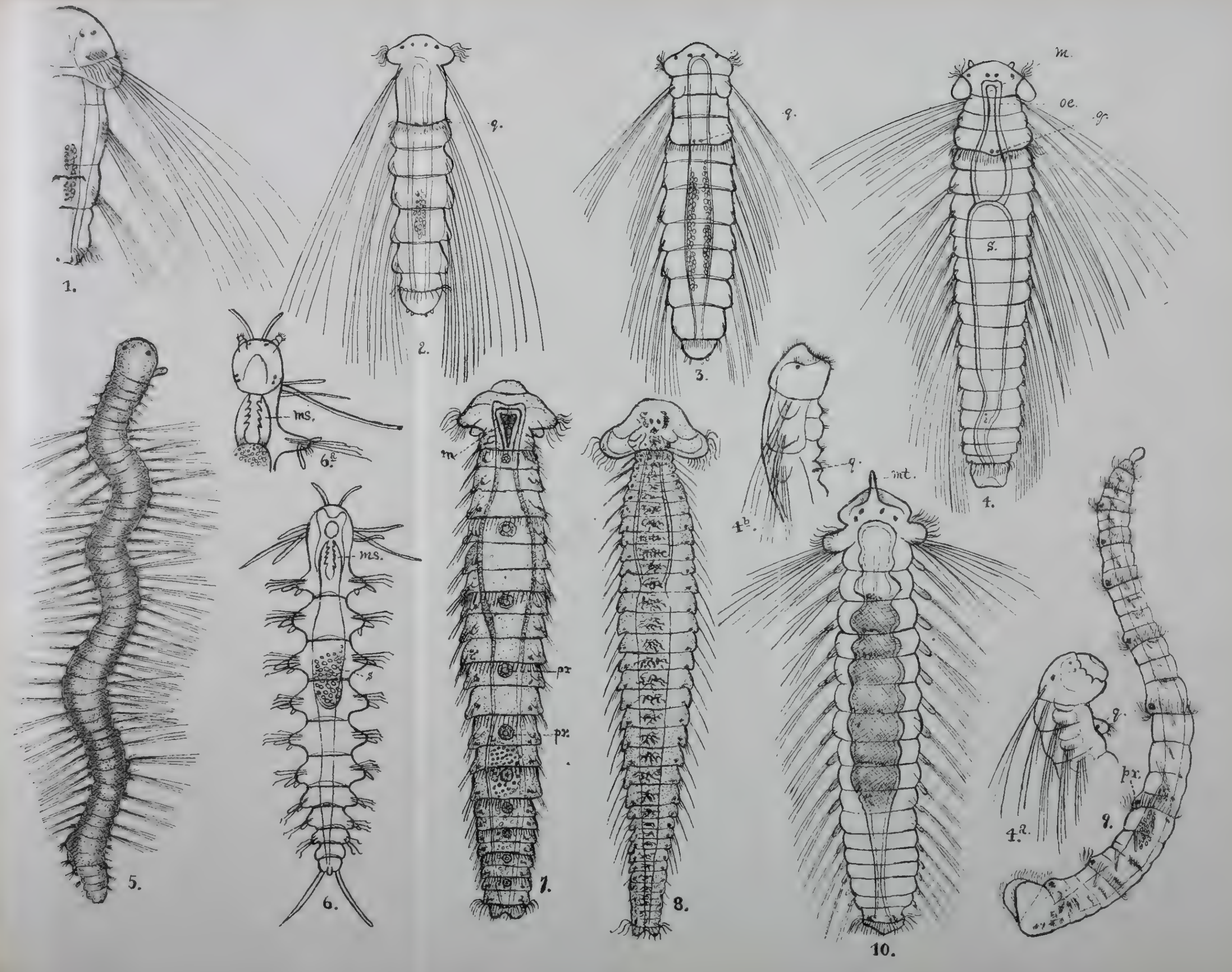
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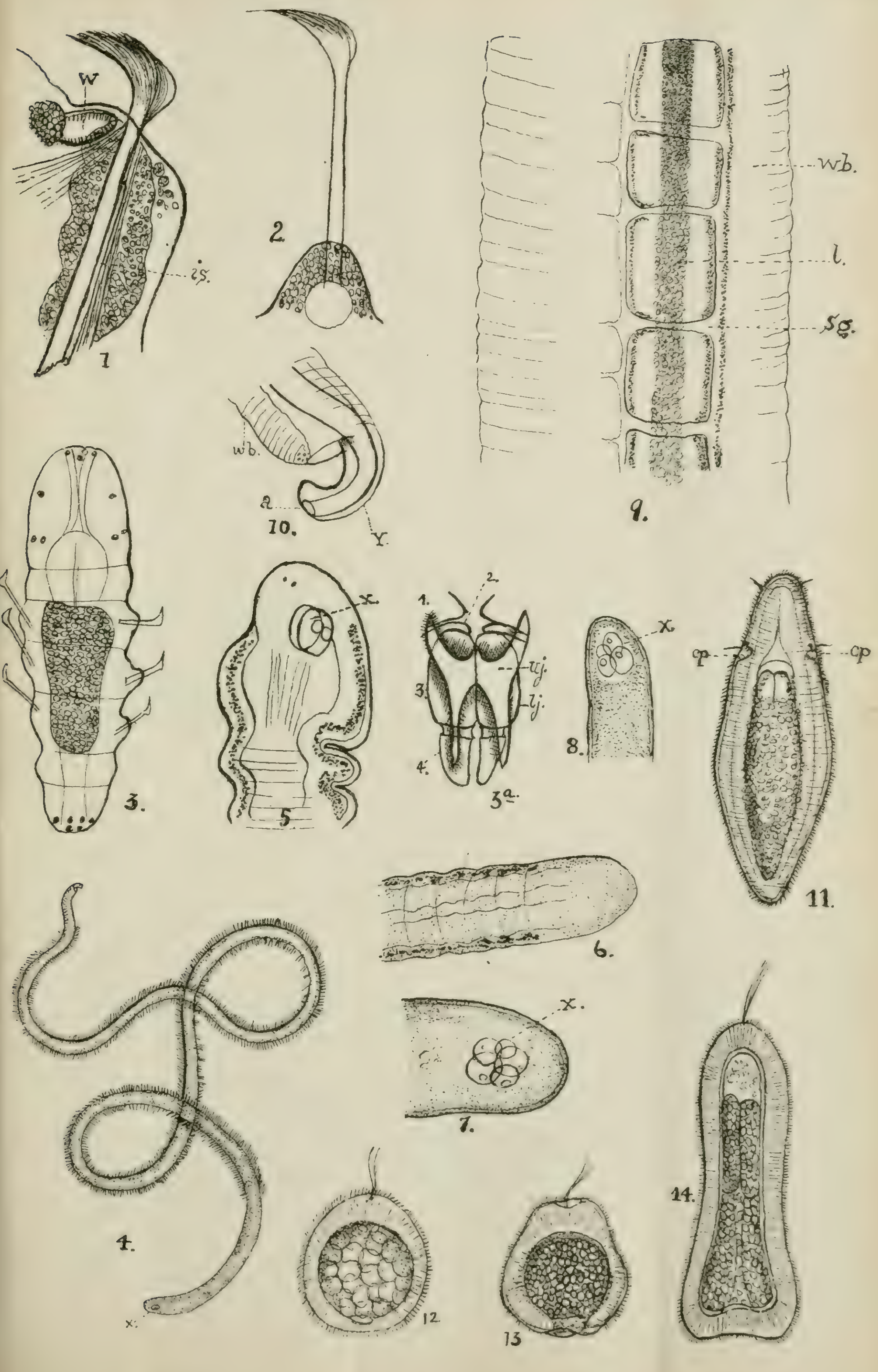
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No. 10. — *Bibliography to accompany "Selections from Embryological Monographs, compiled by* Alexander Agassiz, Walter Faxon, *and* E. L. Mark."

III.*

ACALEPHS.

By J. Walter Fewkes.

The most significant of the early contributions to the embryology of the Acraspeda was the recognition by Sars (M.), in 1853, that the sessile genus *Scyphistoma* Sars, and the free medusa, *Ephyra* Eschscholtz, are larval stages of *Aurelia aurita.* The importance of this discovery was much enlarged by Steenstrup (Joh. J.), who pointed out in 1842 that it was an example of "alternation of generations," similar to that described by Chamisso in *Salpa.* The development of genera of Acraspeda without a fixed larval stage was first described by Krohn (A.) in 1855. A similar direct development has been discovered by Haeckel (E.) in *Aurelia.* Important observations on the development of different genera of Acraspeda have been published by Agassiz (L.), Clark (H. J.), and Claus (C.).

The segmentation and peculiar delamination of the ovum of the Trachymedusæ have been studied by Fol (H.) and Haeckel (E.). The larval forms of the same, more especially of the commensal genus *Cunina*, have been investigated by Gegenbaur (C.), Haeckel (E.), McCrady (J.), Müller (F.), Schultze (F. E.), and Uljanin (B.).

Dalyell recognized the "planula" among the Hydroida. The production of the free medusa known as the gonophore from the fixed hydroid by an asexual method of gemmation was traced by Dujardin (F.) in 1848. The knowledge of a wide distribution of this phenomenon among other genera, and its identity with the method of growth called "alternation of generations," we owe to the researches of Agassiz (A.), Agassiz (L.), Allman (G. R.), Claus (C.), Gegenbaur (C.), McCrady (J.), and others. Kleinenberg's account of the embryology of *Hydra* is the best existing of this remarkable genus.

The Discoidea (*Velellidæ* and *Porpitidæ*) have engaged the attention of many embryologists, among whom are Agassiz (A.), Huxley (T. H.), Kölliker (A.), Pagenstecher (H. A.), Stuart (A.), and Vogt (C.). Gegenbaur (C.) first followed the segmentation of the egg and the early larval stages of *Diphyes*, and Leuckart (R.)

* I. Crustacea. By Walter Faxon. *Bull. Mus. Comp. Zöol.*, IX. 6, p. 197. March, 1882. II. Echinodermata. By Alexander Agassiz. *Ibid.*, X. 2, p. 109. August, 1882.

This bibliography extends to the year 1883 inclusive. Simple descriptions of new hydroids, which add nothing to a knowledge of embryology, are omitted. An asterisk [*] before a title denotes that the work has not been seen by the compiler.

discovered the connection between monogastric (*Eudoxia*) and digastric (*Abyla*) Calycophores. The other most important contributions to the embryology of the Siphonophora are by Agassiz (A.), Chun (C.), Claus (C.), Haeckel (E.), and Metschnikoff (E.).

The embryology of the Ctenophora has been followed by Agassiz (A.), Chun (C.), Fol (H.), Kowalevsky (A.), and Metschnikoff (E.).

CAMBRIDGE, June 1, 1884.

Agassiz, Alexander.

[Development of *Nanomia cara.*] *Proc. Boston Soc. Nat. Hist.*, IX. p. 181. *1862–63.*

[Young of Medusa of *Halopsis ocellata.*] *Proc. Boston Soc. Nat. Hist.*, IX. pp. 219, 220. *1862–63.*

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(Development *passim.*)

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Haeckel's Theory (Allœogenesis) of the Genetic Connection between the Geryonidæ and Æginidæ. *Amer. Journ. Arts and Sci.*, May, *1876. Ann. Mag. Nat. Hist.* [4], XVII. p. 481. *1876.*

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(Younger stages of *Velella* and *Porpita*; *Chrysomitræ* of both; *Rataria* described by Pagenstecher corresponds with young stages of *Porpita.*)

Agassiz, E. C. and A.

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(pp. 21–90 larval stages, *passim.*)

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(Development of *Aurelia aurita.*)

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(Development of *Campanularia.*)

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(Development of *Stenyo*, *Callichora*, and *Syncoryna*, pp. 277, 278.)

Du Plessis, G. *See* **Plessis, G. du.**

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(*Hydra.*)

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(*Lizzia, Zygodactyla, Tima, Eucheilota, Trachynema, Cunina, Agalma, Cyanea, Mnemiopsis.*)

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(Alternation of generations in *Willia.*)

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(Development of tentacular knobs and sexual organs.)

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(*Mnemiopsis, Willia, Phialidium.*)

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(Young of *Tamoya punctata* sp. nov., *Ectopleura* sp. (?); *Ephyra* with sixteen otocysts (young *Cassiopea*); resemblance of sexual clusters of *Rhizophysa* and *Physalia.*)

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(Development of *Eleutheria.*)

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(Development, *passim.*)

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(Development, *passim.*)

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(Budding (*Eucope?*) *gemmifera*, pp. 28, 29.)

Keferstein, W., and Ehlers, E.

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(Development of *Laomedea*, pp. 20–23.)

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НАБЛЮДНІЯ НАДЬ РАЗВИТІЕМЪ. CŒLENTERATA. ИЗВѢСТІЯ ИМПЕРАТОРСКАГО ОБШЕСТВА ЛЮБИТЕЛЕИ ЕСТЕСТВОЗН АНІЯ ТОМЪ X ВЫЩУСКЪ2-Й.

(Development of *Eucope*, *Pelagia*, and Ctenophores).

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(Multiply by budding.)

Lamouroux, J. V. F.

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Exposition Méthodique des Genres de l'Ordre des Polypiers. Paris, *1821.*

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(*Eucoryne elegans* Leidy, produces medusa-like buds.)

Lesson, R. P.

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(Separates hydroids with direct development and those with indirect.)

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(Young *Agalma*.)

De Zoophytorum et Historia et dignitate Systematica. pp. 38. Lipsiæ, *1873.*

(Development, *passim*.)

Zoologische Untersuchungen. Erstes Heft. Siphonophoren. pp. 95, pls. 3. Giessen, *1853.*

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See **Frey, H., and Leuckart, R.**

Lovén, S. L.

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McCrady, J.

Gymnophthalmata of Charleston Harbor. 1857. *Proc. Elliott Soc., Charleston, S. C.*, I. pp. 103–221, pls. VIII.–XII. *1853–58.*

(Commensalist in bell of *Turritopsis* is a *Cunina*.)

Description of *Oceania* [*Turritopsis*] *nutricula* nov. spec., and the Embryological History of a singular Medusan Larva found in the Cavity of its Bell. 1856. *Proc. Elliott Soc., Charleston, S. C.*, I. pp. 55–90, pls. IV.–VII. *1853–58.*

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(Young *Bougainvillea* has no mouth or stomach.)

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Structure et Développement des Nematophores des Hydroids. *Arch. Zool. Experiment.*, X. No. 4, pp. 583–610.

Metschnikoff, E.

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(Larva of *Gleba* (*Hippopodius*).)

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Studien über die Entwickelung der Medusen und Siphonophoren. *Zeitschr. f. wissensch. Zool.*, XXIV. pp. 15–83, pls. II.–XII. *1874.*

(Young stages of *Cunina*, *Polyxenia*, *Agalma*, *Stephanomia*, *Epibulia*, *Halistemma*, *Praya*, and *Hippopodius*.)

Vergleichend-Embryologische Studien. *Zeitschr. f. wissensch. Zool.*, XXXVI. pp. 433–444, pl. XXVIII. *1881.*

(Early stages of development of *Carmarina fungiformis*.)

Metschnikoff, E., and Ludmila.

МАТЕРІАЛЫКЪ ПОЗНАНІЮ СИФОНОФОРЬ И МДУЗЪ. ИЗВѢСТІЯ ИМПЕРАТОРСКАГО ОБЩЕСТВА ЛЮБИТЕЛЕЙ ЕСТЕСТВОЗНАНІЯ, АНТЯОПОЛОГІИ И ЭТНОГРАФІИ. МОСКВА, *1871.* pp. 1–75, pls. I.–VI.

(Development of Siphonophora and Medusæ.)

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anderer niederer Thiere. *Nova Acta Acad. Nat. Cur.*, XVI., Suppl. pp. 125–216, pls. XXVII.–XXXVI. Breslau u. Bonn, *1834*.

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Kurzer Ueberblick der in der Kieler Bucht von uns beobachteten wirbellosen Thiere, als Vorläufer einer Fauna derselben. *Arch. f. Naturgesch.*, pp. 229–237. *1862.*

(*Sarsia tubulosa* develops from *Syncoryne*, p. 231.)

Milne Edwards, H.

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Morse, E. S.

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(*Glossocodon* and *Cunina.*)

Polypen und Quallen von Santa Catharina, *Olindias sambaquiensis,* n. sp. *Arch. f. Naturgesch.*, pp. 312–319, pl. IX. *1861.*

(Larval form has longer tentacles than adult.)

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Cunina Köllikeri, n. sp. Beitrag zur Naturgeschichte der Aeginiden. *Arch. f. Naturgesch.*, pp. 42–52, pl. IV. *1861.*

(Development of *Cunina.*)

Ueber die Randbläschen der Hydroidquallen. *Arch. f. Mikr. Anat.*, I. pp. 143–147, pl. VII., fig. 4. *1865.*

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(Young *Beroë*, direct development.)

Müller, H. *See* **Gegenbaur, C., Kölliker, A., and Müller, H.**

Müller, P. E.

Iagttagelser over nogle Siphonophorer. 1869. *Natur. Tidskr.* [3], VII. pp. 261–332, 541–547, pls. XI.–XIII. Kjöbenhavn, *1870–71.*

(Development of *Eudoxia* and *Diphyes;* describes deformed Spermatozoa direction cells?)

Mummery, J. B.

On the Development of *Tubularia indivisa.* 1852. *Micr. Journ. Trans.*, I. pp. 28–30. *1853.*

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(Acalephæ, pp. 56–70, figs. 46–63.)

Pagenstecher, H. A.

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(Young Siphonophore develops in a mantle out of which it is born with provisional organs.)

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Pillsbury, J. H.

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Plessis, G. du.

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(Describes Planula, Scyphostoma, Strobila, and Ephyra.)

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(Development of Ctenophore without "alternation of generations.")

On the Genus *Cydippe*. *Rep. Brit. Assoc. Adv. Sci., Trans. Sect.*, pp. 155, 156. *1859.*

(Young like adult.)

Quatrefages, A. de.

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(Sexual buds.)

Ray Lankester. *See* **Lankester, E. Ray.**

Reid, J.

Observations on the Development of the Medusæ. *Ann. Mag. Nat. Hist.* [2], I. pp. 25–34, pls. V., VI. *1848.*

(Scyphostoma and Ephyra of *Aurelia.*)

Sars, Michael.

Fremlagde detaillerede Afbildninger, ledsagede med Bemaerkninger over følgende norske Cœlenterater. 1860. *Forhandl. Vidensk. Selsk. Christiania*, pp. 140–151. *1861.*

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(*Cytæis* buds from proboscis; Strobila is young Medusa.)

Ueber die Entwickelung der *Medusa aurita* und der *Cyanea capillata*. *Arch. f. Naturgesch.*, pp. 9–34, pls. 4. *1841*.

(Strobila is young *Aurelia* (*Medusa*) *aurita*; development of *Aurelia* and *Cyanea*.)

Fauna Littoralis Norvegiæ oder Beschreibung und Abbildungen neuer oder wenig bekannten Seethiere, nebst Beobachtungen über die Organisation, Lebensweise und Entwickelung derselben. pp. 94, pls. 10. Christiania, *1846*.

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Fauna Littoralis Norvegiæ (continued).

See **Koren, J., and Danielssen, D. C.**

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Zur Entwicklungsgeschichte der *Aurelia aurita*. *Arch. Mikros. Anat.*, VI. pp. 363–367, pl. XIX. *1870*.

Schultze, F. E.

Ueber die Cuninen-Knospenähren im Magen von *Geryonien*. *Der Naturwissenschaftliche Verein für Steiermark der* 48 *Versammlung deutscher Naturforscher und Aerzte als Festgabe*. pp. 125–157, pl. I. Graz, *1875*

Ueber den Bau und die Entwicklung von *Cordylophora lacustris* [Allman] nebst Bemerkungen über Vorkommen und lebensweise dieses Thieres. pp. 52, pls. 6. Leipzig, *1871*.

Schultze, M. S.

Ueber die männlichen Geschlechtstheile der *Campanularia geniculata*. *Arch. Anat. Physiol. wissensch. Med.*, pp. 53–64, pl. I. *1850*. Trans. *Micros. Journ.*, III. pp. 59–66. *1855*.

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Siebold, C. T. von.

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(Development of *Aurelia*.)

Ueber Parthenogenesis. pp. 25. München, *1862.*

(Refers to alternation of generations in Acalephs.)

Solander, D. *See* **Ellis, J., and Solander, D.**

Steenstrup, Joh. J.

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(Alternation of generations in Acalephæ.)

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Strethill Wright. *See* **Wright, T. Strethill.**

Stuart, A.

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Tilesius, W. G.

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***Tommasi, S.**

Eserciazioni accademiche degle Aspiranti Naturaliste, diretti dal Dott. O. G. Costa. Memorie risguardanti la Zoologia e Anatomia comparata. *1842.*

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О ПРОИСХОЖДЕНИИ КУНИНЪ, ПОЧКУЮЩИХСЯ ВЪ ЖЕЛУДКѢ ГЕРІОНИДЪ. ИЗВѢСТІЯ ИМПЕРАТОРСКАГО ОБЩЕСТВА ЛЮБИТЕЛЕЙ ЕСТЕСТВОЗНАНІЯ, АНТРОПОЛОГІИ И ЭТНОГРАФІИ. ТОМЪ XXIV. МОСКВА, *1876.* pp. 1–16, pls. I., II.

(Development of *Cunina.*)

Van Beneden, P. J. *See* **Beneden, P. J. van.**

Van der Hoeven, J. *See* **Leuckart, R.**

Varenne, André de.

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Ueber die Siphonophoren. 1852. *Zeitschr. f. wissensch. Zool.*, III. pp. 522–525, pl. XIV. *1851–52.* *Ann. Sci. Nat.* [3], XVIII. pp. 273–278, pl. V. *1852.*

(Egg of *Halistemma* (*Agalma*) *rubra.*)

Bilder aus dem Thierleben. pp. 1–452, figs. 120. Frankfurt a/M.

(Development, pp. 146-159.)

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Recherches sur les Animaux Inférieurs de la Méditerranée: Premier Mémoire sur les Siphonophores de la Mer de Nice. Genève, *1854.* pp. 164, pls. 21. *Mémoires de l'Institut National Genevois,* I. [*1853*] *1854.*

(Development, *passim.*)

Ocean und Mittelmeer. Berlin, *1858.*

(Development, *passim.*)

Von Koch. *See* **Koch, G. von.**

Von Siebold. *See* **Siebold, C. T. von.**

Wagner, Rudolph.

Neue im Adriatischen Meeregefundene Art von nacktem Armpolypen. *Isis, 1833.* p. 256.

(Buds of hydroid resemble medusæ.)

Weismann, A.

Zur Frage nach dem Ursprung der Geschlechtszellen bei den Hydroiden. *Zool. Anzeig.*, III. Nr. 55, pp. 226–233. *1880.*

Ueber den Ursprung der Geschlechtszellen bei den Hydroiden. *Zool. Anzeig.*, III. Nr. 61, pp. 367–370. *1880.*

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(Development, *passim*, hydroids.)

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No. 11. — *Studies from the Newport Marine Zoölogical Laboratory. Communicated by* ALEXANDER AGASSIZ.

XV.

On the Development of Agalma. BY J. WALTER FEWKES.

THE genus *Agalma*, in its growth from an egg into the adult, passes through three larval stages which can be readily distinguished from each other. These larvæ, from the nature of the growth of the *Agalma* colony, are not separated from one another by clearly marked distinctions, but temporary organs found in one stage are often carried over to the next in the course of the passage of one larva into that next following. The peculiarities, however, of each are strongly enough defined to justify the division of the embryological history of *Agalma* into the three stages to which reference is made.

These three characteristic larvæ about which the young of the genus *Agalma* group themselves have been given the following names: 1. The primitive larva; 2. The Athorybia stage; 3. The larva like the adult in general features, although possessing together with organs of the adult certain provisional structures bequeathed to it from the earlier conditions of growth through which it has passed.

The last two of these larval stages are not considered in this paper, except incidentally to record observations on certain appendages of the Athorybia stage, showing the fate of organs of permanent and others of provisional nature which play an important part in the appearance of the youngest or primitive larval condition. The present contribution deals with the outward changes in the growth of the egg from fertilization to the primitive larva. In that epoch many important organs, some of which persist into the adult, originate; and, more significant still, at that time first arise the three layers out of which every organ of the whole colony is developed. The development of the first of the three larval stages of *Agalma* may consequently be looked upon as a key to the phylogeny of the Oceanic Hydrozoa. It is therefore at all events necessary, before we can trace the relationships of different genera widely

or closely related to *Agalma*, to know accurately the changes in external form which the ovum passes through in these genera. Upon such knowledge we can hang our speculations regarding the possible descent of the members of the Siphonophora one from another, or from a common ancestor.

The species of *Agalma* which has been studied is the only *Agalma* thus far recorded from New England waters. It is called *Agalma elegans*, and was first described by the author. When this animal was first taken, in 1876, I regarded it as the same as the "form (b)" of *Agalmopsis elegans* Sars, or closely related to it.

Early Changes of the Egg before Segmentation.

The earliest changes in the egg take place, in all cases observed, while it is enclosed in the female gonophore.* These go on with great rapidity, as will be shown by the following statements. Specimens of *Agalma* captured on August 6, at noon, were found four hours later to have dropped their gonophores, from which had come ova segmented in the 4-cell stage. It must be mentioned, however, that by transferring the *Agalma* from the sea into aquaria they were placed in unnatural conditions, so that changes in temperature and other causes may have accelerated or retarded their rate of growth. There is nothing to show that there are not other kinds of segmentation besides that which is here described.

* In a popular article on the development of *Agalma elegans*, published in the American Naturalist for March, 1881, certain changes in the germinative vesicle which were mistaken for segmentation were spoken of. This interpretation was erroneous, and the true segmentation was not described. On p. 188, *op. cit.*, the egg is spoken of as cast into the water and there impregnated. There is nothing to prove that this is the case in *Agalma*. It has, however, excellent support in the history of observation. Gegenbaur, Beiträge zur näheren Kenntniss der Schwimmpolypen (Siphonophoren), p. 49. Writing of the genera *Agalmopsis*, *Forskalia*, *Physophora*, *Hippopodius*, and *Diphyes*, he says: "Die Befruchtung erfolgt erst nach dem Austritte der Eier aus der Eikapsel; denn niemals fand ich Samenfäden in letzere eingedrungen, eben ausgetretene Eier dagegen stets von ihnen umschwärmt. Sie sassen dann strahlenartig mit dem Köpfchen an der Peripherie des Eies an, mit dem Fadentheile selbst in zitternder Bewegung." I have not been able to observe a similar condition in *Agalma*, nor was a free egg with nucleus and nucleolus found floating in the water. In one instance these bodies were observed to vanish while yet the ovum was in its gonophore, while the stalk of the same was attached to the parent. All eggs found free from the gonophore are destitute of these structures.

Four hours after an *Agalma* was placed in the aquarium, eggs in the 4-cell stage were picked out of the water in which it was confined. I have traced one and the same egg from the 2-cell to the 4-cell stage, and find that it takes 2 h. 10 m. for the necessary changes to be perfected in this growth. On another egg it was determined that it takes 45 m. to develop an egg in the 2-cell stage from an egg in which the germinative vesicle, or "nucleus," had disappeared. By this observation it will be seen that it requires a little over an hour to pass from the egg just fertilized into the stage which exhibits the first sign of a primitive cleavage, plus the interval of time which elapses after the 2-cell stage is formed and before it begins to form the secondary furrow, or origin of the second cleavage-plane. This last interval is probably not more than 30 m.; consequently the interval which elapses after fertilization before the formation of the primary furrow is about half an hour.

Impregnation probably takes place in the gonophore. I have not been able to fecundate the *Agalma* egg artificially, nor was it seen to take place naturally. I have repeatedly tried to fertilize ova with sperm from the same colony, but have always failed. This fact led me, in 1880, to state that the animal cannot be impregnated by spermatozoa from its own male bells. Last summer (1884), however, to obtain some information on this point, an isolated *Agalma* was kept in a glass jar, and it dropped eggs which became segmented and later developed into primitive larvæ. The water in which it was confined was not changed meanwhile, nor new liquid added. Of course this experiment does not absolutely demonstrate that the spermatozoa from the same colony can or cannot unite with an unfecundated ovum of the same, for sperm may have been in the water before the animal was placed there. Experimentation on the subject has many difficulties; but it must be confessed, that, as far as I have thus far gone in my studies, it looks as if the male bells of an *Agalma* may sometimes fertilize ova from the same axis. The great difficulty in the artificial fecundation of the *Agalma* egg was pointed out by Metschnikoff.* The ovum in the gonophore is enclosed in what he calls an "Umhüllung," from the walls of which the tender egg cannot be extracted without harm to its contents.

The first naturalist to fertilize artificially the Siphonophore egg was Gegenbaur.† Metschnikoff ‡ was equally unsuccessful with myself with

* Studien über die Entwickelung der Medusen und Siphonophoren. *Zeit. f. Wiss. Zool.*, XXIV. p. 49.

† Beiträge zur näheren Kentniss der Schwimpolypen (Siphonophoren), p. 49.

‡ *Op. cit.*, p. 49.

the egg of *Agalma*. Haeckel * says that he made attempts to fertilize artificially the ova of the genera *Praya*, *Diphyes*, *Abyla*, *Hippopodius*, *Athorybia*, *Agalmopsis*, *Halistemma*, *Forskalia*, *Crystallodes*, and *Physophora*. "Die Mehrzahl der Versuche schlug fehl, und in vielen Fällen gingen die befruchteten und sich entwickelnden Eier zu Grunde. Ehe sie noch über die ersten bereits von Gegenbaur beschriebenen Entwickelungstudien hinaus die Entwickelungsvorgänge zu verfolgen, gelang mir nur bei drei Physophoriden-Gattungen, nämlich bei *Physophora* (bis zum XXVIIIsten Tage), *Crystallodes* (bis zum XXVIIsten Tage), und bei *Athorybia* (bis zum VIIten Tage)." He does not state with sufficient exactness in the case of *Crystallodes*, the nearest ally of these three genera to *Agalma*, whether he artificially impregnated the ovum or not.

The natural ovulation in *Agalma* was the only means of getting material for the study of the embryology; and as this happened seldom, even in instances when I had in confinement a large number of large and sexually mature specimens, the amount of material at my control was small. The youngest larvæ are very hardy, needing, for early stages at least, no change of water, provided decaying matter from the adult animal be not allowed to pollute it.

Each ovum is carried in a bell-shaped structure called the female gonophore. The female gonophores (Pl. I. fig. 1) are found in botryoidal bunches at the base of the polypites, and generally adhere to the neighboring hydrophyllium when it is broken from its attachment to the stem. The gonophore is fastened to the axis by its apex, through which a small tube communicates between a system of vessels called the radial tubes and the cavity of the stem. No marginal tube or marginal appendages of any kind were detected on the bell. The course of the radial tubes in the bell of the female gonophore (Pl. I. fig. 3) is very irregular, and varies very greatly in different individual gonophores. In a form of gonophore which was common, the following arrangement in the disposition of the tubes was observed. Two radial tubes arise from a common point under the apex of the bell, at the junction of the same with the tube of the apex. These lie in opposite hemispheres on the walls of the bell cavity. Consider the course of one of these radial tubes. After extending from under the apex of the bell about half-way down the sides of the bell on its inner surface, it bifurcates, each division passing at right angles to the course of the undivided tube. Each of the bifur-

* Zur Entwickelungsgeschichte der Siphonophoren. Eine von der Utrechter Gesellschaft für Kunst und Wissenschaft gekrönte Preisschrift. Utrecht, 1869. p. 10.

cations passes around the bell parallel with the margin, and joins a corresponding bifurcation from the undivided tube of the hemisphere opposite that in which the bifurcation first described takes place. Before these bifurcations join, however, each sends a loop downward, which approaches the neighborhood of the bell margin, but eventually returns to the bifurcation.

The single ovum lies in a thin-walled sac,* which hangs from a point directly under the apex, and when ripe fills the whole bell cavity, sometimes projecting a little through the opening. The free gonophore is propelled in the water by violent contractions of the walls of the bell.

The male gonophore, like the female, is often found free in the water in which the *Agalma* is confined. When attached to the stem it is found in clusters at or near the base of a taster midway between two adjacent polypites. In many live specimens of *Agalma* some of the attached male gonophores will be found to have milk-white contents. Like the female, the male gonophore is commonly transparent.

The bell of the male gonophore is more elongated and larger than the female. It measures 2.5 mm. in length and .4 mm. in greatest diameter. At the apex of the bell there is a short peduncle by which it is attached to the adult. Through this peduncle there extends a tube, — the peduncular tube. There are are four thread-like simple radial tubes which have a direct course in the bell walls and unite with a circular marginal vessel. Each male gonophore has a narrow, thin velum. The bell walls are capable of quick contractions when free from the axis.

* Whether the egg in the gonophore is surrounded by a membrane by which it is held there, or not, no one has clearly proved. I think such is the case. In the first place, the homology of the gonophore with the gonophores of other genera which have an ovisac would seem to point to such a condition in *Agalma*. In my figure of the egg just escaping from the gonophore a structure was observed in the bell cavity which called to mind the ruptured walls of such a sac. After the ovum was cast, there is reason to suppose that the "sac" is retained in the gonophore. Metschnikoff speaks of the egg of *Agalma* as "membranlos." Haeckel says the egg-cell of *Crystallodes*, "wie bei den übrigen Siphonophoren ist ganz nackt," and that of *Physophora*, "wie die Eier aller übrigen Siphonophoren sind dieselben durchaus hüllenlos." "*Hippopodius gleba*," writes Metschnikoff (*op. cit.*, p. 46), "ist die einzige mir bekannte Siphonophore, deren Eier mit einer freilich äusserst dünnen Membran überzogen sind." *Hippopodius* and *Vogtia*, according to Kölliker, have ovisacs in which, when in the gonophore, *numerous* ova are contained. I have also observed in a *Eudoxia* which resembles *E. Lessonii*, that here also we have *numerous* ova in an ovisac in the female gonophore, and there are many other similar observations on record.

The larger part of the cavity of the male bell is taken up by an ovate, slightly opaque mass, which is a sac inflated with spermatozoa. This sac, like the sac which carries the ovum, fills almost the whole cavity of the bell. The distal pole of the sac is closed.

Free spermatozoa are obtained in great quantities by simply pressing the body of the sac of the male gonophore, when they escape through the ruptures in the walls. The spermatozoa are the ordinary tailed variety with rounded, often pyriform heads, which are sometimes prolonged into a pointed end opposite the tail.

In the smaller female gonophores (Pl. I. fig. 1), and also in some others of larger size, we recognize in the contained egg a transparent cell, germinative vesicle, in which is a dot, and sometimes within the last are one or more granules. The mass of the egg, however, is formed of a clear substance, through which there extends a protoplasmic network, imparting the appearance of a complex spongy mass of polygonal cells to the egg contents. This network has not been figured or specially described by others in the egg of *Agalma*, although it has been seen by Metschnikoff and figured by him in *Epibulia*, *Stephanomia*, and *Halistemma*. Although he neither figures nor specially describes this network in *Agalma*, Metschnikoff* may have referred to it when he says: "Die vollkommern reifen membran- und kernlosen Eier [of *Agalma*] zeigen eine ähnliche Zusammensetzung wie die oben beschreibenen Eier der *Epibulia aurantiaca* und des *Hippopodius gleba*, unterscheiden † sich aber von ihnen durch ihre feinen röthlichgelbe Färbung, welches sie dem Vorhandensein eines diffusen Pigmentes verdanken." I shall return to these "cells" later, in my account of the progress of the growth of the egg.

Precisely how the spermatozoön comes in contact with the ovum, if the latter is placed in a closed sac, is somewhat of a puzzle. The germinative dot and vesicle disappear before this sac is ruptured. At about this time one or two globules (*p g.*) were observed on the egg. In my figure the nucleus and nucleolus have not disappeared. These changes go on so fast, that I am not confident that both are found together, and the globules may have appeared after the disappearance of dot and vesicle. These globules seem to be the same as the "deformed spermatozoa" described in another genus by P. E. Müller. If the disappearance

* *Loc. cit.*, p. 49.

† The statement of Metschnikoff, p. 46 (quoted above), that the eggs of *Hippopodius gleba* "mit einer freilich äusserst dünnen Membran überzogen sind," would seem to be another difference.

of the clear cells denotes that fecundation has occurred, how have the spermatozoa effected an entrance into the egg? The germinative vesicle and dot disappear probably before the gonophore is detached from the axis of the adult, and, without doubt, before the egg leaves its gonophore. In the immature gonophore in which the body *p g.* was seen, the opening into the bell cavity of the gonophore had not formed. Whatever the cell *pg.* may be, spermatozoön or polar globule, both germinative dot and vesicle disappear before the ovum leaves its gonophore. If this event is a result of an impregnation, there seems to remain but one conclusion, — namely, that the fertilization of the ovum takes place in the gonophore. We are led to suppose that the spermatozoa either penetrated the sac walls of the ovum and gonophore, or passed through the apical canal, which is not in free communication with the surface of the ovum. It seems more natural to adopt the latter supposition, unless we suppose that nucleus and nucleolus vanish before impregnation. The cell, with its enclosed cellular body, which we have called the nucleus and nucleolus, disappears and leaves the egg of homogeneous appearance, with the contents made up of the protoplasmic network of cells already mentioned. The next change is that by which the egg separates itself from the sac in the gonophore in which it is contained.

Several authors have commented upon the peculiar sinuses which are sometimes found at this time in the female bell about the egg. These sinuses are of many shapes, and lie between the egg and its membranous sac (Pl. I. fig. 2). They have the appearance of spaces left here after preliminary movements of the ovum before escape from the gonophore, or by a shrinkage of the walls. A single gonophore (fig. 4) was observed in which the ovum was in the act of escape; and in that gonophore the folded remnant of a structure, which may be the sac which formerly enclosed the egg, was seen just under the apex of the bell in its cavity. The diameter of the opening into the cavity of the bell was in this instance observed to be smaller than that of the egg, so that the egg in some instances suffers a considerable compression before it escapes from the cavity of the gonophore. After the egg leaves the gonophore it assumes a spherical form, with a diameter of .45 mm. (Pl. I. fig. 6). One pole is ruby in color, the other transparent. The network of protoplasm which extends through the entire contents imparts to it a cellular appearance, while a thin layer, probably of protoplasm, is found over its entire surface.

Cleavage.

First Cleavage Furrow. — Gegenbaur,* who says that he observed the segmentation of the ovum of the genera *Agalmopsis*, *Physophora*, *Forskalia*, *Hippopodius*, and *Diphyes*, states that the whole process of segmentation is finished in from twenty-four to thirty-six hours. Haeckel† says that in *Physophora*, *Crystallodes*, and *Athorybia* the segmentation is finished at the end of the second day. Metschnikoff does not state the exact limit of time when the segmentation is finished, although from the age of the youngest larva of *Agalma* which he figures I should judge that the segmentation was accomplished in the second day. All recorded observations on Siphonophore eggs point to the conclusion that the cleavage is wholly completed before the beginning of the third day after fecundation.

My first specimen of *Agalma* was captured on August 6th, at noon, and before the morning of August 8th it had laid eggs which were in the same stage as that figured by Metschnikoff on the fourth day. In other words, a little over a day and a half after the *Agalmata* were placed in the aquarium, eggs from them had segmented and had formed the two layers described by Metschnikoff in the changes of the fourth day. My observations are thus at variance with those of Gegenbaur, Haeckel, and Metschnikoff. What is the meaning of the discrepancy? Looking over my notes in vain to find an error in this particular, it has seemed possible that errors of observation have crept in for the reason that individual eggs have not been followed through their consequent stages. An *Agalma* in captivity will mature its eggs at different times, so that at the end of the fifth day segmented eggs in company with those which are far along in the development of the primitive hydrophyllium may be picked out of the same water. From the nature of the case, unless individual eggs are isolated and the time of their fecundation recorded, it is impossible to know the age of any specified stage.

The first change which takes place in the spherical egg after it has left the gonophore is the formation of the primary cleavage furrow, *pr.* At one pole of the ovum (Pl. I. fig. 7) an indentation appears in the form of a furrow on the surface of the egg. Although I have not observed at the outset the exact relationship of this furrow to the rosy pole, I have seen that later, after the first plane of cleavage has been

* *Op. cit.*, p. 50.

† *Op. cit.*, for *Physophora*, p. 19; for *Crystallodes*, p. 51; for *Athorybia*, p. 89.

completed and the egg is in the 2-cell stage, this plane passes through a rosy pole. While this gap in observation is too important to be overlooked in studying the relation of the primitive plane of cleavage to the poles of the egg or the axis of the adult animal, enough has been observed to show that the first plane of cleavage passes through the pole of the egg adjacent to that part of the sac which is attached to the gonophore, if the rosy pole of the egg in the 2-cell stage and that of the egg in the gonophore are the same. We are able to identify a rosy pole in the egg, even into those post-segmented stages when the embryo begins to push out the two layers of the primitive hydrophyllium on the surface of the yolk; and while we have not traced the continuity of this pigment in an egg in this stage with the segmented egg older than the 8-cell stage, the presumption is that the poles are the same in both cases.

The primary furrow, *pr.*, bending into the ovum on one side of the *Agalma* egg, causes many obscure or sharply defined folds on each side. Similar plications are also mentioned and figured by Metschnikoff * in *Epibulia.* The egg at this time as shown by Metschnikoff in the latter genus resembles the ova of *Geryonia* and the Ctenophora.

As the groove on the animal pole deepens, changes in the external contour of the egg follow with great rapidity. I have timed the duration of a few of these variations, and give camera drawings to illustrate their appearance at intervals of time.

At 8 h. 45 m. in the morning the indentation which marks the appearance of the primary cleavage furrow has just begun to appear. The egg at this stage is smaller than that just laid, but whether this diminution in size is due to the changes which result from the formation of the primary furrow or individual variation, we have no data by which to determine. The diameter of *this* egg in the plane connecting the pole where the furrow has taken place with the opposite is .30 mm.; the longer diameter is .35 mm. The profile of the egg, looking at it in a plane at right angles to the primary furrow, is oval or slightly notched at one pole.

Fifteen minutes later, at nine o'clock A. M. (Pl. I. fig. 7), the profile of the same egg in the same position has become still more heart-shaped, and the primary furrow has deepened to an amount greater than the radius of the egg. The depression forming the primary furrow almost girts the egg, extending over the surface for more than two thirds its circumference.

* *Op. cit.*, p. 40.

At 9 h. 10 m. A. M. (Pl. I. fig. 8) the primary furrow, *pr.*, has deepened still more, and the constriction has encroached more than before on the whole circumference, so that now the two hemispheres of the egg are connected by a narrow band or "bridge" of protoplasm, the breadth of which is about .05 mm. The longer diameter of the egg is .35 mm.; the shorter, .25 mm.

At 9 h. 20 m. A. M. (Pl. I. fig. 9) the constriction has grown wholly around the egg and the primary furrow has deepened so much that a small protoplasmic band .02 mm. in diameter is all that now connects the two cells. The other dimensions are about the same as the corresponding diameters of the egg at 9 h. 15 m. A. M. (fig. 9), although it was noticed that one hemisphere of the 2-cell stage was slightly smaller than the other.

At 9 h. 25 m. A. M. (Pl. I. fig. 11) the cell which was the smaller has grown in size so that now both cells of the 2-cell egg are of uniform size. At 9 h. 30 m. A. M. (fig. 12) the two cells have been pressed closely together, and the first plane of cleavage (1 *cl. pl.*) has been fully formed, although the undivided part of the egg still remains in the form of a slight bridge connecting the two cells which form the egg. No nuclei were observed in either of the cells.

It will thus be seen that the development of the 2-celled ovum from the time the primary furrow first appears up to that when the first cleavage plane is well formed is forty-five minutes. For a long time after the formation of the first cleavage plane has been effected, both hemispheres of the egg exhibit abnormal changes by which the egg is made to assume curious, often grotesque forms. Here and there over the surface of the egg rise pseudopodic elevations, which sometimes take the form of long rhizopodal threads. Later, these extensions sink back into the substance of the egg and new combinations arise. The two spheres, or hemispheres, now draw away from each other, or become squeezed together. They lose their globular, symmetrical form, and their profiles become more angular, or sometimes the angles are pushed out into conical projections. These changes often foretell the immediate death of the egg, but full as often take place in healthy ova which reach a good old age.

A considerable length of time may elapse before the initial changes leading to the formation of the second plane of cleavage can be detected. We are not in my judgment justified in supposing that the vital forces of the egg are "resting" at that time until we know more accurately the state of the interior and the changes which are going on there.

This is the nearest approach which we have in the *Agalma* egg to a "resting stage."

Second Cleavage Furrow. — How much time intervenes after the formation of the first cleavage plane before signs of a second furrow appear, has not been accurately observed. It is thought to be about thirty minutes. In a stage of segmentation, not raised from that just described, but like it also in the 2-cell stage, it was possible to follow the whole progress of the growth of the second furrow. This egg was not raised from those formerly described, but was picked out of the water, and was observed in the 2-cell stage on the fourth day after the *Agalma* was captured. At 1 P. M. (fig. 13) it showed the first trace of the second cleavage furrow, and an hour later the egg had passed into the 4-cell stage. The changes of that hour are as follows as far as external form goes.

If we suppose this egg to be placed in such a position (fig. 13) that the first plane of cleavage (1 *cl. pl.*) is vertical, there will be observed on one side of this plane, viz. in the left-hand cell, a slight depression or furrow (*se.*) indicated at first by a variation from a straight line which the plane seen in profile seems to have. This depression is caused by the infolding of the surface of the egg at that point, and is the beginning of the second cleavage furrow. The furrow is at first at right angles to the primary furrow, and in its earliest condition one cell only of the 2-cell stage is modified.

At 1 h. 10 m. P. M. (*se.*, Pl. I. fig. 14) the growth of the furrow is very slight. The depression has deepened, the chasm widened, and folds similar to those described in the walls of the primary furrow have been developed.

At 1 h. 15 m. P. M. (Pl. I. fig. 15) the second cleavage furrow (*se.*), while extending itself and deepening in the left-hand cell, has appeared also in the right-hand as well. It is now no longer placed at right angles to the primary cleavage plane, but lies across it at an angle of from 60° to 65°. A slight predominance in size of the left-hand end of the furrow is shown in the figure. The diameter of the egg at right angles to the first plane of cleavage is now about .60 mm.; the shorter diameter, about .45 mm.

The growth of the egg in the next three minutes is important. At 1 h. 18 m. P. M. (fig. 16) the second furrow has lengthened and deepened, growing in such a way as to produce a certain twisting in the first plane of cleavage. A contortion of the first cleavage plane, 1 *cl. pl.*, is brought about by the growth of the second furrow. In an egg seen

in the same plane as in former instances, the line indicating the first plane of cleavage, which in them was unbroken, is bent at right angles at the point where the secondary furrow has appeared. The second cleavage furrow is at this time a little over .15 mm. long. The longer diameter of the egg is .60 mm.; the shorter, about .45 mm.

The general appearance of the egg two minutes later than the last, or at 1 h. 20 m. P. M. (fig. 17), although in most respects similar to it, has several marked differences, the result of the progressive growth. One of the most striking of these differences is the still greater increase in the amount of the deviation from a straight line which now separates the lower end of the upper line from the upper end of the lower vertical, both being the profile of the first cleavage plane, 1 *cl. pl.* The length of the second cleavage furrow, *sc.*, has now increased to .25 mm., its breadth remaining about the same, and in its sides are frequent plications running parallel with the first cleavage plane, much more sharply defined than in any which has preceded it. Up to the present time (fig. 17), twenty minutes after the first visible changes by which we pass from an egg with two cells into one with four, the secondary furrow has been limited in its extension. It now slowly deepens, and at the same time grows along the surface of the ovum toward the equator, although at 1 h. 20 m. it has not yet extended far enough to reach the periphery of the egg as seen in profile. There is as yet no indentation marking the limit of the second cleavage groove on the equator of the egg.

In the same egg five minutes later, at 1 h. 25 m. P. M. (fig. 18), the second furrow, *se.*, is found extending across the whole hemisphere, and is represented in the figure by the large horizontally placed furrow. The size and depth of this indentation may be estimated by the depression at either extremity of this furrow. In profile it is seen to equal in depth the radius of the egg. Like the primary groove, *pr.*, this likewise eventually extends almost through the egg, dividing it into two symmetrical hemispheres connected by an undivided "bridge." The walls of the furrow, still grooved with cleavage folds, have not yet begun to approximate. In this stage (fig. 18), although we seem to have four segmentation spheres, the second plane of cleavage does not extend more than two thirds across the diameter of the egg as seen from the original surface of infolding. On the side of the egg away from the observer, the 2-cell stage was slightly grooved by the second furrow. The sides of the second cleavage furrow have not yet begun to draw together. At this time in the growth of the ovum the walls of the

second furrow on each side, and especially at the peripheral extremities, or that part most distant from the primary plane of cleavage, exhibit rhizopodal elevations similar to those which accompany the formation of the primary furrow, and which we shall later see are found to form especially in later stages of growth, wherever a new plane is about to appear. Similar rhizopodal phenomena are also premonitory of death in the cells of the egg.

At 1 h. 30 m. P. M. (fig. 19), half an hour after the secondary cleavage furrow began to appear, the secondary groove (*se.*) shows signs of closing, and the walls draw together to form the second cleavage plane (2 *cl.pl.*). The closure of the secondary furrow takes place in substantially the same manner as the primary, and begins at the junction with the primary, working gradually to the periphery. All the time that the growing together of the sides of the furrow is going on, as the movement of closure advances towards the equator it is accompanied by the formation of new folds and the pushing out of pseudopodia in the line of its advance. In my figure representing the egg at 1 h. 30 m. P. M. these folds can be seen in the left hand of the figure, where the furrow is only partly closed.

By the closure of the second furrow, combined with the contortion which is thus caused in the primary plane of cleavage, the profile of the first plane (primary), *pr.*, appears zigzag, or the line which was formerly vertical is now not straight from one pole to the opposite, but is broken midway in its course. As this vertical marks the direction of the primary cleavage plane (1 *cl. pl.*), we have indications that the primary cleavage plane, once intact, is now broken or bent. That modification in this plane can be recognized in later stages of development, being seen as late as the 8-cell stage. The diameter of the egg on the primary cleavage-plane is about .60 mm.; on a plane at right angles, .45 mm. The segmentation spheres have no visible nuclei. The great mass of the ovum is transparent, and the part surrounding the upper end of the vertical line, which is the primary plane of cleavage, is of a rosy color.

The next stage of cleavage, 1 h. 35 m. P. M. (fig. 20), thirty-five minutes after the beginning of the modification of the 2-cell stage, differs very slightly from that just described. The second cleavage furrow (2 *cl.pl.*) is now closed almost to its very periphery, although protoplasmic elevations are seen at intervals along the furrow, a sure sign that the process is not yet completed. Remnants of the unclosed furrow are seen at each end of the horizontal furrow (2 *cl. pl.*).

At 1 h. 45 m. P. M. (fig. 21) the protoplasmic forces are still active in sending out the rhizopodia, and the secondary cleavage plane (2 *cl. pl.*) is not wholly formed, and at 1 h. 55 m. P. M. (fig. 22) the 4-cell stage is practically complete, although here and there, as at the left of the figure, a slight protoplasmic elevation can be seen. The second plane of cleavage is practically formed.

An hour and ten minutes, 2 h. 10 m. P. M. (fig. 23), after the 2-cell stage we have an egg divided into four cells by two planes at right angles to each other. None of these cells have a nucleus, and all are still penetrated by the network of "cells" which we have already described in the unsegmented ovum. The vertical plane passes through a rosy region of the egg; the opposite pole is more transparent. The diameter of the egg on the first cleavage plane is a little less than .50 mm.; on the opposite plane, about .45 mm. Although on the face of the egg which is before us the ovum is divided into the 4-cell condition, I have not been able to observe the opposite pole. Subsequent stages seem to indicate that the secondary plane does not extend wholly through it, but that at the opposite side there still remains an undivided surface. Later changes in the general outlines of the ovum lead me to suspect that the undivided part, either by growth or protoplasmic extension, is of considerable size after the formation of the 4-cell stage.

Third Cleavage Furrow. — The appearance of another cleavage furrow on the same egg, the third which has been traced, was first noticed at 3 h. 15 m. P. M. (Pl. II. fig. 3), two hours and thirty minutes after the 2-cell stage. In the mean time certain changes in the contour of the egg which are not fully understood had taken place. At 3 h. P. M. (Pl. II. fig. 1) the primary (1 *cl. pl.*) and secondary (2 *cl. pl.*) planes of cleavage, represented by the vertical and horizontal planes, occupy the same relative position as formerly, and the right-hand cells are in the main the same in contour. On the side of the left-hand cells, as figured, away from the observer, has appeared a large undivided lobe (*ct.*), a little smaller than the original left-hand cell of the 2-cell stage. The egg has probably been slightly rolled on its axis, by which the large undivided lobe is turned into sight, whereas formerly it was concealed behind the two left-hand cells of the 4-cell stage. I was not able to observe satisfactorily the origin of this large lobe. The only explanation which can at present be given to account for its existence is one suggested above, that it is the bridge or connecting band which has not been divided by the second cleavage furrow. If, however, its fate

resembles that of the protoplasmic bridge of the primary furrow, my explanation is probably erroneous.

The large lobe is the point of origin of a new cleavage furrow, which I have called the tertiary or third cleavage furrow (3 *cl. pl.*). In the general structure and mode of origin the third cleavage furrow bears a striking likeness to the primary and secondary. It forms at right angles to the direction of the second furrow and parallel with a part of the first furrow in the large undivided lobe on the left-hand side. At 3 h. 5 m. P. M. (Pl. II. fig. 2) the tertiary furrow had not begun to appear; but ten minutes after, at 3 h. 15 m. P. M. (Pl. II. fig. 3), it had reached a considerable size. Like the primary and secondary furrows, the walls of the tertiary are formed by an infolding of the surface of the ovum, and have the characteristic sharply defined folds and plications already mentioned.

Figures of the egg at 3 h. 20 m. P. M. (Pl. II. fig. 4), and at 3 h. 25 m. P. M. (fig. 5), are introduced in order to show the progress of the growth of the tertiary furrow in the division of the large undivided lobe on the left-hand side of the egg. At 3 h. 30 m. P. M. (fig. 6) two hours and a half after the formation of the first cleavage furrow, the tertiary furrow has divided this lobe horizontally into two smaller cells. The portion of the tertiary plane which bisects the large lobe is, like the primary and secondary, perpendicular to the plane of the paper on which the egg is figured. The two axes of the egg, a vertical, which is the original cleavage plane, and the horizontal, the secondary plane, are easily distinguished, and at one end of the tertiary furrow, now almost completely closed in, there is figured a marked protoplasmic elevation. This stage is a 6-cell stage, composed of the four cells which have already been mentioned and the two additional which have just formed. The tertiary furrow was the third furrow observed, but I suspect that between the secondary and tertiary (by my nomenclature) the large lobe which I have represented as divided by this furrow was constricted from the two left-hand cells by another, whose growth was not observed.

Morula.

The complications in the growth of the ovum after the stage last mentioned make it very difficult to follow the birth of new segment spheres or cleavage planes. The last stage of the egg in which the course of the original cleavage can be traced with any certainty is at 3 h. 45 m. P. M. (Pl. II. fig. 7), or two hours and three quarters after the

formation of the first cleavage, when we have an 8-cell stage. From this we pass into morula stages, in which additional cleavage planes were not successfully traced as they originate, and in which the primary and secondary planes could not be recognized as such.

Before leaving the stage (fig. 7) in which the egg was found at 3 h. 45 m. P. M., let me mention an appearance in the egg which was not understood, but which may have a significance in the embryology of these animals. At the point in the egg adjacent to the break which has taken place in the direction of the primary furrow, a depression is formed which resembles an opening leading into the interior of the ovum. From the arrangement of the cell walls in the immediate vicinity, it seemed as if this opening was formed by the drawing apart of the walls of the cells, but whether it is the result of decay or not cannot be at present stated. The single egg in which it was observed, however, afterwards died before passing into advanced larval conditions.

It is at about this time in the development of the *Agalma* egg that some of the most extraordinary examples of protoplasmic elevation from its surface were observed. The resulting changes in external form often baffle all attempts to observe accurately the normal outlines of the cells of the segmented egg. These rhizopodal prominences are most clearly marked in those eggs which have been in long captivity, and seem wholly different in different ova.

Before closing our account of the segmentation, let us compare our observations with those of other naturalists on the same or closely allied genera. The poverty of our knowledge of the segmentation of the egg of the genus *Agalma* is so great, that I find few descriptions in the writings of others available for comparisons. Metschnikoff, although not figuring the segmentation of the egg, evidently observed it, as the following mention indicates. He says,* "Die Dotter zerklüftung, resp. Larvenbildung findet auf dieselbe Weise statt, wie ich oben für *Epibulia aurantiaca* angedeutet habe und wie sie bei allen von mir beobachteten Siphonophoren als Regel gilt. Was aber die Vorgänge der Organbildung betrifft," he continues, "so finde ich die meiste Analogie mit den von Haeckel untersuchten *Crystallodes rigidum* und *Athorybia rosacea*, obwohl auch in dieser Beziehung *Agalma Sarsii* manches Eigenthümliche darbietet." Turning for further information to his account of the segmentation in *Epibulia* we find him devoting a few significant paragraphs to this interesting process. He says,† "Die bald auf das freie Ablegen (es gelang mir nie künstlich aus dem Schlauche befreite Eier

* *Op. cit.*, p. 49.

† *Op. cit.*, pp. 40, 41.

zur Entwickelung zu bringen) folgende Eizerklüftung beginnt nur an einem Pole, in einer Weise, wie ich oben für *Geryonia* angegeben habe. Es bildet sich an dem besagtem Ort eine Furche deren Wände durch eigenthümliche Falten ausgezeichnet werden, welche ein deutliches Zeugniss von der Festigkeit der peripherischen Protoplasmaschicht abgeben. Die besagte Furche vertieft sich in Meridianaler Rechtung gegen den anderen Pol zu, das ganze Ei in zwei Hälften zertheilend, die nur durch eine Brücke zusammengehalten werden. Schliesslich zerfällt das Ei in zwei gleich grosse sog. Furchungskugeln, ohne dass an ihnen irgend eine Spur der originalen Entstehungsweise erhalten bleibt. Das zweikugelige Ei zerfällt auf eine ähnliche Weise in vier Theile, welche sich wieder vermehren, und der sog. regelmässige Zerklüftungsprocess setzt sich weiter fort, bis das Ei in Eine mehrzellige vermittelst der Flimmerhaare freischwimmende Larve verwandelt wird." This account of the segmentation process in *Epibulia* is certainly the best which we have of this period in the development of any Siphonophore. It is, however, the history of the growth of the egg of a Calycophore, while *Agalma* is a Physophore. The value of a comparison of the two is of greatest importance in phylogenetic studies of the respective groups, as showing how close this process is in widely different genera. The segmentation of the Siphonophore egg, as followed by Gegenbaur and Haeckel, differs considerably from that of *Agalma*. The description of the former naturalist is short, but concise. Segmentation was observed by him in several genera. He says:* "Num folgt rasch die Theilung des Dotters, die mit dem Auftreten einer ringförmigen Furche um den Aequator des Eies sich einleitet. Dies wiederholt sich dann an jedem Theilungsproducte, bis das ganze Ei aus einer Masse gleichartiger Furchungskugeln besteht, die ihm das bekannte 'Maulbeerförmige' Aussehen verleihen. In 24–36 Stunden ist der ganze Process vollendet. Ein hier besonders genau zu verfolgender Umstand ist die jedesmalige Theilung des Keimbläschens, welche der Theilung des Dotters vorausgeht; in gleicher Weise verhalten sich dann auch die Theilungsproducte des Keimbläschens zu der Bildung neuer Dotterkugeln." The division of the "Keimbläschen," which was not observed in *Agalma*, is thus reported in at least one genus by Haeckel. In *Physophora* he says:† "Ich kann diese positive Beobachtung Gegenbaur's, welche für die theoretisch wichtige Frage von der Continuität der Zellengenerationen von hoher Bedeutung ist, durch mehrfache eigene Beobachtungen bestätigen.

* *Op. cit.*, pp. 49, 50.

† *Op. cit.* for *Physophora*, p. 18; for *Crystallodes*, p. 51; for *Athorybia*, p. 89.

Der ersten Halbirung des Eidotters geht die Halbirung des Keimbläschens, und dieser wiederum die Halbirung des Keimfleckes voraus." The segmentation of *Crystallodes*, he says, "ist nicht wesentlich von demjenigen der *Physophora*-Eier verscheiden, welchen wir oben bereits geschildert haben." And later, "Der Furchungsprocess des Eies weicht bei *Athorybia* nicht von der oben geschilderten Eifurchung von *Crystallodes* und *Physophora* ab."

Development of the Primitive Covering-Scale.

Epiblast, Hypoblast. — The morula (Pl. II. fig. 8) now becomes covered with a granular layer of ciliated cells whose origin was not observed. This layer is thickest at one pole, where its walls have a reddish color. It has well-marked granular nuclei, which with acetic acid (Pl. III. fig. 2) are found most abundant at the rosy pole. The rosy pole of the segmented egg with its investing layer is supposed to be the same as the rosy pole of the first cleavage plane, and will be spoken of as the "germinative pole," or the "area germinativa." In *Crystallodes*, according to Haeckel,* it is "ein kreisrunder dunklerer Fleck, und zwar an derjenigen Stelle der Oberfläche welche dem späteren aboralen oder proximalen Pole der Längsaxe entspricht. Dieser Fleck, der Fruchthof (*area germinativa*) genannt werden kann, ist bedingt durch eine rasche Vermehrung der Zellen an dieser Stelle der Oberfläche." Metschnikoff † says in his account of the development of *Agalma:* "Die erste embryologische Erscheinung bei der freischwimmenden vier Tagen alten Larve besteht in der Ablagerung einer peripherischen Ectodermschicht, welche jedoch auf einer Hälfte des kugeligen Körpers (die ich fortan als die obere bezeichnen werde) viel dicker als auf der anderen ist. Am folgenden Tage kommt auch das Entoderm zum Vorschein, sich unmittelbar unter der verdickten Stelle der äusseren Schicht concentrirend."

The earliest appearance of the superficial layer in *Agalma elegans* was not observed to be confined to one pole, but in the youngest stages observed the layer completely surrounds the egg; it is only later, *dm* (Pl. III. fig. 1), that it thickens at the pole known as the germinative pole. There is a noteworthy fact in the growth of *Agalma*, that, whenever a new organ is formed on the surface of the *Agalma* egg, we have a concentration of the reddish pigment at that place, while the color, when present, is more diffused on other parts of the egg. This law holds good

* *Op. cit.*, p. 53.

† *Op. cit.*, pp. 49, 50.

in the formation of that polar elevation which marks the origin of the primitive hydrophyllium, the first-formed organ of the larva. The various designations which have been used in the nomenclature of the two poles of the egg in this and following stages admit of misinterpretations. If we call the pole at which the increase of the thickness in the surface layer takes place the upper pole, we convey a wrong impression as to its natural position in the water; for if we observe the position in which the egg floats in stages a little older, it will be seen that the so-called upper ("obere") pole is always downward, as it naturally would be brought in equilibrium by the increase in weight resulting from the growing organ. Not less misleading are the terms oral and aboral. When the mouth of the first-formed polypite appears, it is in a position 90° from that pole (the *area germinativa*) at which the primitive hydrophyllium first forms. The aboral pole is therefore 90° from the position assigned to it, if the terms have anything more than an arbitrary significance. The rosy color seen at one pole of the unsegmented egg dates from the time when the ovum was in the sac within the gonophore. At that early stage the pole of the ovum opposite the attachment of the sac is rosy in color, and through all stages of cleavage up to one with eight cells that same rosy pole has been recognized. Here (8-celled stage) the relations to the axis were lost; but a rosy region was still to be seen, and it seems legitimate to conclude that the rosy pole is identical in these cases, rather than that the color has migrated from one region of the ovum to another in unseen stages intermediate between those submitted to exact observation. Moreover, going a step farther, can we not also regard that pole where the single layer is beginning to thicken, and which has the same reddish color, as identical with those which we have studied? I think we can suppose that the rosy color in this stage indicates the same pole which is marked out by it at the very beginning, — the same, in fact, through which the first cleavage plane was observed to pass. Although I have spoken of this pole as the germinative pole, its axis is not the same as the axis of the adult animal. The investing layer spread over the surface of the egg is thickest at the germinative pole, and diminishes in thickness gradually to the opposite pole. The thinning out of this layer is a regular diminution on all sides; and up to the present time there are no right and left sides to the layers which cap the germinative pole.

In the next stage (Pl. III. fig. 3) following the last, the ovum, instead of being spherical, has become more elongated, assuming the form of a prolate sphere, and the portion directly under the germinative pole has

been raised by a slight constriction, forming a swelling on the external surface. At this time we can distinguish two layers, *eb.*, *hb.*, in the undivided single layer of the former stage, while between them, as they lie one above the other, there is a slight thin crescent-formed space, which later increases in size, and is filled with a third layer. The elevation, apparently three-layered, with the part of the yolk immediately below it, forms a disk-shaped body with concave surface resting upon the spherical egg. This disk hangs downward as the egg floats in the water. In another egg (Pl. III. fig. 4) of about the same age, the shallow constriction which marks off the disk from the remainder of the egg is somewhat magnified. Although the general outlines of this embryo are distorted (the constriction being too deep), the stage is an interesting one as showing on one side a slight notch which has appeared in the outer layer, *eb.* The existence of this notch enables us to determine certain primary axes, formerly not distinguishable, on the surface of this larva, which have relations to the axis of the adult *Agalma.* Before passing to this point, let me say that the outer of the two layers is the epiblast, the inner the hypoblast, and the layer of the intermediate chamber the middle layer (*mb.*), later constituting the gelatinous mass of the hydrophyllium. The custom of looking at the float as a starting-point for reference of organs, and using the terms proximal and distal in reference to this structure, has been adopted in the writings of some naturalists. This nomenclature can as well be followed here in the larva as in the adult. The float, although in *Agalma* it is not the first structure to appear, can be regarded in the young, as in the adult, as situated at a fixed point or pole for reference when studying other organs, since in all genera it is the first permanent structure which appears.

It will be found in the subsequent history of our larva, that the float develops near by a region of the disk opposite to that in which the notch in the outer of the two layers lies. We can approximately say that in Pl. III. fig. 4 it will appear just below the indentation on the left hand, as the figure is drawn. The whole of the disk-shaped elevation which has formed on the egg and destroyed its sphericity lies, therefore, on one side of the future float. That side may be called the germinative side, for on it appear one by one all the remaining organs of the *Agalma* body. They have, however, at first no regularity in the position in which they form. Using the nomenclature which has been suggested, the notch is on the distal side of the disk, as it is most distal from that pole of the ovum later to be occupied by the float. The hemisphere of the ovum which faces the observer may be called the right side, as referred

to an axis passing through float and distal rim of the elevation, and that opposite the left, for reasons which will soon appear.

The larva is now a little over two days old. The many cleavage planes, *cl. pl.*, forming the polygonal segmentation spheres in the yolk are clearly defined. The protoplasmic network, *vt. c.*, throughout the ovum, is likewise still well marked. The outer of the two layers, or the epiblast, is ciliated externally. At the elevation on the germinative pole it has a reddish color. The layer beneath the epiblast, or the hypoblast, is thinner than the more superficial. A horizontal diameter of the egg is .45 mm.; the longest axis at right angles to it, and passing through the germinative pole, is .55 mm. Both epiblast and hypoblast together at the thickest point are not more than .01 mm. in thickness.

In a slightly older larva (Pl. III. fig. 5) the significance of the notch at the distal rim of the primitive elevation of the germinative area becomes more apparent. The epiblast and hypoblast, formerly of about the same thickness, have in this stage somewhat changed their relative dimensions, and when seen in profile are observed to have assumed folds which are of significance in the shape of the future covering-scale. The epiblast on the distal side of the disk-like elevation has thickened, and two well-marked angles appear on its exterior. Its surface on the distal side rises by a smaller angle from the yolk surface than on the proximal, and slopes away more gradually to the opposite side. The hypoblast hugs the yolk cells at all points except at one place (*c. p. l.*), where it rises from them, leaving a recess which is later the cavity of the primitive larva. Near by this cavity the hypoblast is slightly separated from its enveloping layer, the epiblast, by a middle or third layer. The two angles found on the surface of the epiblast at the distal rim of the forming disk have grown more prominent, as shown in the two following sketches (figs. 6, 7), and the two layers have separated more and more from each other.

When looking at the egg in its present stage of development, we notice at once how sharp the difference is between the proximal and distal portions of the rim of the disk-like elevation. They differ very much in shape from each other; and this difference is magnified as we follow the course of the development into older larvæ. In the light of what is known of the existence of bilateral symmetry in the adult *Agalma*, we may regard this difference in the two borders of the scale as among the earliest expressions of that condition. The forming disk possesses a proximal and distal border, and therefore a right and left side, as referred to a line passing through these regions. This line lies in the same plane

as the axis of the adult *Agalma*, although it is not clear that the right and left sides of the disk-like elevation correspond with the right and left sides of the appendages later found on the adult *Agalma* axis. The general appearance of the yolk and the size of the egg is approximately the same as in the preceding stages. The right and left sides used for figures up to Pl. III. fig. 4 have not the same significance as here interpreted.

The next oldest larva (fig. 9) differs primarily from the last in the greater elevation and prominence of the layers formed on the yolk. The epiblast and hypoblast are much thicker; the former has a reddish, the latter a yellowish color. The constriction around the elevated disk between its edges and the surface of the ovum has deepened on the distal side of the elevation as seen in profile, but the indentation is very slight on the proximal side.

Within the disk a gelatinous layer, so transparent as to be invisible, has formed by a separation of the epiblast and hypoblast. The thickness of this layer is greatest near the distal end of the disk. Yellow and reddish pigment is found in the epiblast on the surface of the yolk sac. It was also noticed that the epiblast at *pn. cy.*, near the proximal end of the elevated disk, is much thicker than that near the distal side, and that there was a tendency to form a slight epiblastic elevation at that point. If the reader will compare the figure of this stage with one of about the same age by Metschnikoff, he will find a great difference in external shape between the two. My larva is approximately the same as Pl. VIII. fig. 5 in the oft-quoted work by that author, who says that his larva is five days old. My adult *Agalma* was put in the aquaria on August 6, and the stage represented in fig. 8 was found free in the water on August 8, or two days later. I likewise picked out of the same water three days after, or five days after the adults were put there, larvæ of the same age, while with these were still others much farther advanced, and some which were just passing through the early stages of segmentation of the egg.

I find a discrepancy, which may be a generic difference, in the rate of growth day by day recorded in Haeckel's observations on the development of *Crystallodes*, and Metschnikoff's of *Agalma*. In larvæ of *Crystallodes* four days old the float was as far advanced as in the *Agalma* six days old of Metschnikoff, while on the second day both the *Agalma* and *Crystallodes* larvæ were still in a morula stage. These discrepancies arise from the difference in the mode of growth of the float in the genera, or from the fact that different clusters of eggs, or different members

even of the same cluster, mature at different times. We must not suppose, in studying the development of *Agalma* eggs, that the ova found free in the water were all cast at the same time. The only trustworthy method of observation is to trace individual eggs into larvæ and time their development, which is a most difficult thing to accomplish successfully with these tender creatures. Even if we follow and time with care the rate of growth in our glasses, it is a question whether we should not make an allowance for retardation or acceleration of this time brought about by changes in the temperature of the water in which they are placed in our aquaria.

The disk formed at one pole of the egg by the epiblast, hypoblast, and an intermediate transparent layer, may be called the primitive hydrophyllium or covering-scale, to distinguish it from others which are later formed. In a stage following the last this body has assumed an elevation upon the surface of the egg greater than formerly. As far as its general outlines go, no great change has taken place in the larva with advancing age; but near the rim of the disk another minute elevation in the walls of the epiblast has pushed itself up, which is destined later to play an important part in the structure of the adult. This elevation (*pn. cy.*), which at this time cannot be distinguished from a simple bud such as any other organ of the *Agalma* body at first has, is the beginning of the future float. It is a true bud, as already pointed out by Metschnikoff.

The accounts which Metschnikoff and Haeckel give of the origin of the float in genera so nearly related as *Agalma* and *Crystallodes* are radically different. In *Crystallodes*, according to Haeckel, the air-sac originates from the primitive cavity as a bud. Speaking of changes on the sixth day, he says: * "Die wichtigste Veränderung aber, welche am sechsten Tage eintritt, ist die vollständige *Abschnürung des Luftsackes* von dem Centralraum der Primitivhöhle. Das Entoderm, welches die Wand des Luftsackes bildet, und welches bisher an seiner Einmündung in die Centralhöhle unmittelbar überging nach oben in das Entoderm des Deckstück-Nährcanals, nach vorn in das Entoderm des Polypiten, wächset nun vollständig an dieser Stelle zusammen. Der Larvenkörper enthält also nunmehr zwei vollständig getrennte und geschlossene, mit Flüssigkeit erfüllte Höhlen: die einfach rundliche oder längliche runde Luftsackhöhle, und die Centralhöhle, welche in vier Canäle sich verzweigt, in die Canäle der beiden Knospen, des Deckstücks und des Polypiten. Das Entoderm, welches alle diese Höhlräume auskleidet,

* *Op. cit.*, p. 58.

ist eine einschichtige Lage von Flimmerepithel. Dasselbe erscheint bei durchfallendem Lichte bräunlichgelb, bei auffallendem Lichte spangrün gefärbt. Der Luftsack selbst ist rings von den hellen Zellen des Nahrungsdotters umgeben, und steht nur an seinem proximalen Ende (der Abschnürungsstelle) in Berührung mit der Wand der Polypitenbasis, welche daselbst in das Deckstück übergeht."

In the genus *Agalma* Metschnikoff thus describes the appearance of the float on the fifth day. He says: * "Zu gleicher Zeit bemerken wir dicht unterhalb des Deckstückes, auf der Fläche, die ich als Rückenfläche bezeichne, eine locale Ectodermverdickung, welche als erste Spur des Luftapparates angedeutet werden muss. Am sechsten Tage hat sie die Form eines halbkugeligen Körpers angenommen, der unter der äusseren Ectodermbedeckung und in der Nähe des einstweilen noch localen Entoderms seine Lage findet." The origin of the float in *Agalma elegans* resembles more closely that of *Agalma Sarsii* than that of *Crystallodes*. It arises as a simple epiblastic elevation of the yolk surface, not far from the proximal side of the hydrophyllium. That elevation is primarily of epiblast, but later the hypoblast may also enter into its formation. As the float grows older, the bud diminishes in size, thickening inward, and a separation of the hypoblast from the epiblast takes place, which is filled by an intermediate body, either thickened epiblast or the intermediate or middle layer. The subsequent growth of the float will be seen in descriptions of later stages of the primitive larva.

In Fig. 13 we find that the primitive hydrophyllium has increased very much in size, while in the progress of that growth the distinction between the proximal and distal edges of the disk which we have earlier detected are still maintained. The great body of the scale is gelatinous, the mass of which is formed by an enormous growth of a middle layer (*mb.*), which lies between epiblast and hypoblast. The relative thickness of the epiblast has greatly diminished. It is still ciliated and easily distinguished from the other layers when seen in profile and along the rim of the hydrophyllium, while scattered over the surface of the scale appear the small epiblastic structures or nuclei (?). The forming covering-scales called serrated hydrophyllia (*ser. hyph.*) have a slightly red color.

The primitive cavity (*c. p. l.*) lined with hypoblastic cells which have a distinct yellow color has risen with the growth of the bell, and extends towards the distal rim of the hydrophyllium. The edges of the disk are free, the hydrophyllium fitting over the egg like a helmet, the visor

* *Op. cit.*, p. 50.

being represented by the distal border. In the proximal region of the primitive hydrophyllium we find that the epiblast and hypoblast have separated from each other, and that between them has formed a layer or cellular mass representing the great gelatinous mass of the medusa bell. Outside of it is the epiblast, while lining the cavity is the hypoblast. The latter layer can be traced from the lining of the primitive cavity for some distance over the surface of the yolk cells under the epiblast. The epiblast can also be traced from the superficial position on the yolk over the surface of the hydrophyllium. I find by a comparison of this figure with those by Metschnikoff representing the first appearance of the float, that it most closely approaches his Fig. 6, Pl. VIII. In his figure, however, we miss a representation of the inner hypoblast between the bud which forms the float and the yolk cells which were seen in the stages here figured. Comparing, however, his Fig. 5 of the same plate with his Fig. 6, we find in the latter an ectodermic bud but no hypoblast, while in the former a layer continuous with the lining of the primitive cavity lies under the epiblast where the float is developed. His Fig. 6 represents the origin of the float as far as the epiblast goes like mine, but we miss in it a deeper layer of hypoblast which is probably present. The epiblast at this stage probably divides into a superficial and a deeper portion. It is suggested that the latter is the same as the middle or gelatinous layer of the medusa bell.

Under the visor at the distal rim of the helmet-shaped hydrophyllium of Fig. 13 the layer of epiblast is thicker than in most other regions, and has a reddish color. Its surface is rough by reason of elevations, which are probably superficial, uprising from the epiblast. At this point, or near by, the serrated hydrophyllia (*ser. hyph.*) characteristic of the second larval stage of *Agalma* first appear. The diameter of the primitive hydrophyllium from distal to proximal border is .40 mm.; its elevation above the yolk, .15 mm. The diameter of the egg is .47 mm. These larvæ were picked out of the water in which the *Agalmata* were confined at six o'clock, August 8th. The hydrophyllium naturally floats downward in the water, the yolk being apparently lighter.

Primitive Larva. — The maximum development of the primitive or larval hydrophyllium is reached in the next stage, represented in Fig. 14. In this larva the yolk of the egg is still spherical, and little reduced in size, notwithstanding the enormous growth of the scale from it. The helmet-shaped hydrophyllium almost completely invests the ovum. The bounding planes of the irregular polygonal cells of segmentation are

clearly to be seen through the side of the hydrophyllium, and the enveloping layers of the yolk are traceable over its whole surface. Within the segmented yolk cells appears the protoplasmic network (*rt. r.*) which dates back to the original ovum in the gonophore. The primitive hydrophyllium is seen fitting over the ovum like a helmet, which, although fastened to it at the germinative pole, is free on the sides. Its border and sides cover about two thirds of the yolk which is here represented through the transparent lateral walls.

The primitive hydrophyllium is transparent, slightly reddish in certain regions, its great bulk being gelatinous. The following distinction between the distal and proximal rim can be easily seen when in profile. The wall of the distal edge, which corresponds to the visor of the helmet of our former comparisons, is much thicker than the opposite, and more rounded. The proximal rim ends in a sharp angle, and its walls are very thin. In a figure of this stage we have the larva represented as if we were looking at it from the left-hand side as defined above. Over the surface of the primitive hydrophyllium is spread a single layer of thin polygonal cells of the epiblast, which are seen in profile around the rim of the bell and on its bounding lines, even on the inner surface adjoining the yolk sac. Over the external surface the prominent nuclei of the same cells can be readily traced, dotting it at intervals, and in places well-defined cell-walls can be faintly seen. The layer from which these cells came, or the epiblast, was one of the first layers to form, and throughout the growth it has been gradually becoming relatively thinner and thinner. Although the bodies called nuclei of these cells are very well marked in *Agalma elegans*, I do not find them represented in the figures which have been published of other species of the genus *Agalma*, or *Crystallodes*. The remnant of that cavity, which has been called the primitive cavity, is now a tubular body with thickened hypoblastic walls of yellow color, and extends from the base of the float towards the distal portion of the hydrophyllium.

At this stage in the development of the primitive hydrophyllium it was observed that from the nuclei of several of the epiblastic cells, situated on the surface of the hydrophyllium above the fundus of the cavity, there were thread-like extensions, probably protoplasmic, which connect the surface of the larva with the hypoblast of the cavity. At times the surface of the hydrophyllium from which these threads arise is depressed as if forcibly drawn back by them. In a few instances the threads end blindly in the gelatinous layer at a point not more than half-way from the epiblast to the cavity. These threads sometimes

have a close resemblance to certain similarly placed threads in worm larvæ, as in the well-known *Tornaria*, where they extend from the cavity of the larva to an apical cluster of modified epiblastic cells through an intermediate gelatinous layer. I was unable to observe these threads closely enough to detect any tubular structure in them. Later in the growth of the larva there are two filiform bodies connecting the cavity of a hydrophyllium with its surface, which may possibly be the same as the thread-like extensions of which we have already spoken. In the development of *Agalma Sarsii* as figured by Metschnikoff, we have no representative of these threads in the primitive larva, or in stages of later growth. Hæckel figures certain structures in the hydrophyllium of *Physophora* which have been found by me in *Agalma*, which in *Physophora* have the form of small tubes extending from the cavity to the surface. These call to mind the protoplasmic bodies in the primitive hydrophyllium of *Agalma*, although they are different in many respects. Hæckel gives them a morphological significance in *Physophora*, and regards them as comparable with certain parts of the chymiferous radial tube system of hydroid gonophores. He does not represent them in the younger forms, at least, of the primitive larva of *Crystallodes*. Cilia were not observed on the outer surface of the primitive covering-scale, but were seen on the epiblast covering the yolk at this age.

Of the remaining structures found in the primitive larva the most important in the future history is a spherical organ (*pn. cy.*) adjacent to the end of the primitive cavity. This body is the future float, and at this stage lies inside the egg, or between the yolk cells and the superficial covering, although no marked external elevation could be seen. The float is enclosed by a layer of cells which was traced continuously into the hypoblast of the primitive cavity, and also into the hypoblast which covers the yolk sac. Within the hypoblast the contents of the float and the hypoblastic layer were slightly separated. A continuation of the same layer, epiblast, reflexed from the inner surface of the covering-scale, extends over the float and is continued over the surface of the egg.

A second appendage, which assumed the form of a slight projection from the surface of the yolk on the left-hand side of the cavity of the primitive hydrophyllium, is also present in this stage of the primitive larva. In profile this structure (*scr. hyph.*) is arch-shaped, and has a slightly reddish color. It is the beginning of a covering-scale which, although provisional in nature, has given the name of "Athorybia stage" to a larval condition of *Agalma* which follows the first or primi-

tive larva. On the right-hand side of the cavity of the primitive hydrophyllium is a cluster of cells of red color, which is the beginning of a second similar serrated hydrophyllium. This latter cluster, however, has not raised itself any considerable amount above the surface of the yolk. The longest diameter of the primitive hydrophyllium in Fig. 14 is .75 mm.; the thickness at the distal side, .17 mm. The length of the primitive cavity is .25 mm.; its breadth is .10 mm. The float is almost .10 mm. in diameter. It will be seen from these measurements that the scale has now reached a very great size as compared with its dimensions in earlier larvæ. It has now the maximum size to which it ever attains.

Fate of the Primitive Hydrophyllium.

It is known that this primitive hydrophyllium is a temporary or embryonic structure; but its fate, whether it is simply thrown off or absorbed, is not at present definitely made out. Both Hæckel and Metschnikoff have pointed out that it is a provisional structure, but neither has traced it far enough in the last phases of its history to satisfactorily show whether it is simply discarded, absorbed, or passes with external changes of outline into some other structure. The most definite statement which we have is as follows. Metschnikoff says, "das erstgebildete kappenförmige Deckstück abgeworfen wird" in the genus *Agalma.*

The primitive hydrophyllium of *Agalma elegans* suffers many modifications in external form in some of the older stages; but whether these modifications were abnormal, resulting from the fact that the animal is in confinement, was not determined. It seems to me more natural to suppose, that, instead of being thrown off in the subsequent stages, the primitive covering-scale passes by a few modifications in its external contour into some other organ, probably a differently formed covering-scale.

Fig. 15 represents the larva of *Agalma* on August 10, four days after the capture of the parent. This larva was picked out of the water, in which it was freely swimming below the surface. The figure represents the larva as seen from that pole which is opposite the germinative pole, so that the various organs which have appeared near that region are seen through the yolk contents. This position, assumed while the egg is floating, is that which is best adapted to exhibit the

newly forming organs in their relation to the cavity of the primitive hydrophyllium.

We recognize in this stage many organs which have already been described, and one or two new ones lately formed. In the first place, the yolk — a prominent spherical mass of polygonal segmentation spheres with the internal protoplasmic network — should be mentioned. This occupies most of the middle portion of the figure. Around it in profile the epiblastic and hypoblastic layers, of which the former is ciliated, may be seen. The larger, more transparent body, seen above and on either side of the yolk, is the projecting primitive hydrophyllium. This distal portion of this scale is represented at the top of the figure, the proximal at the lower part, while the right hand of the figure is the left of the scale, following the nomenclature of previous descriptions. The nuclei of the epiblast and the polygonal outlines of the epiblastic cells are easily seen here and there over the surface of the scale. The cavity (*c. p. l.*) of the primitive larva has two or more thread-like structures (*fil.*) extending from its hypoblastic lining to the nuclei of epiblastic cells. The hypoblast of the primitive cavity has a yellow color, especially well marked at its distal end, where its walls are likewise covered with small pigment dots, black, or nearly so, in color. At the opposite extremity of the primitive cavity, near the float, it ends in a closed cone-like termination, which is hidden by the float in the figure.

It is perhaps needless to say, that the spherical body near the middle of the figure is the float, seen through the yolk contents; and that on the right and left sides of the primitive cavity are two buds, which later develop into the serrated hydrophyllia characteristic of the Athorybia stage. In both of these can be recognized a very thick outer layer, which is probably the middle gelatinous layer, over which is spread a thin layer of epiblast, and an inner thinner layer, which is hypoblast. Within this last layer in each case we have a cavity which is the beginning of the future tube which penetrates the scales. A considerable quantity of reddish pigment is found in the yolk in the immediate neighborhood of the last-mentioned organs. It is very difficult for me to formulate any law for the relative position in which the successively appearing buds of the larva of the *Agalma* develop. We know that in the adult *Agalma* those nectocalyces which are nearest the float are the youngest, and that the newly formed organs of this name always develop between those already formed and the float.

Fig. 2, Pl. IV. represents a very instructive stage in the development of the primitive larva, which was taken on August 9 at noon, or on the third

day after the capture of the adult. It is seen in a little different plane from the preceding, but in such a way that the organs already mentioned can be easily distinguished. We have in this stage an addition of most important character, for at this time first appears the beginning of the polypite. The larva is shown in such a way that the embryo is twisted somewhat as compared with former stages, and the hydrophyllium has its proximal edge so turned into view as almost completely to cover the yolk. By this new position of the larva the conical end of the primitive cavity near the float is well shown, while the two buds which later form the serrated hydrophyllia are thrown to one side. The most developed of these last-mentioned organs has a spatulate form, and shows the three layers, epiblast, middle layer, and hypoblast, as well as a cavity which occupies most of the interior of the organ. The other hydrophyllium is not as well formed, and is more highly colored.

In addition to the buds which have been mentioned as already formed, we have represented in this stage a significant thickening (*pyt.*) at one pole of the two layers which surround the yolk of the egg. This pole is situated in a point at right angles to that where the bud which forms the float first appears. The elevation of these two layers takes the form of a simple bud comparable with other buds of the primitive larva, and ultimately forms the first or primitive polypite of the *Agalma*. The elevation of the primitive polypite is reddish yellow and ciliated, with the lower layer slightly separated from the cells of the yolk. Although the point at which the polypite in *Agalma* develops is very different from that at which the same organ of *Crystallodes*, as recorded by Hæckel, arises, these differences are not too great to have a similar morphological interpretation. Like all organs or parts of the *Agalma* body, the polypite originates as a three-layered bud from the surface of the yolk. Like them also it separates from the yolk-cells, leaving a cavity between the hypoblast and vitelline cells. A part of those walls of the yolk which enclose the yolk-cells becomes the outer wall of the float; another part is modified into new buds, which develop into tasters, hydrophyllia, and tentacles; and still another part forms the walls of the first-formed polypite. Can we not consider that the yolk-sac in this case, as in *Crystallodes*, is not changed into the polypite, as in *Physophora* and some other genera?

From Fig. 16, Pl. III., taken five days after the capture of the *Agalma*, we may obtain a somewhat better idea of the relationship between the buds which form the float, the serrated hydrophyllia, and the first-formed polypite. In the view of the larva as here seen, we are looking at the

larva from the side opposite that on which the primitive hydrophyllium is attached. The primitive cavity is thus thrown behind the yolk, and is concealed by the buds which have already appeared, one of which is shown in profile. The larva is placed in what is considered its normal position comparable with the natural position of the adult. The float is well developed, and resembles closely that of the adult. Below it there is a well-marked red pigment-spot on the external walls of the ovum, which forms a convenient point for the orientation of other organs, and which itself forms in later stages a well-known organ (embryonic tentacle); and at the pole of the egg opposite the float we find the partly formed polypite. The lower part of the large transparent body behind the yolk is the distal rim of the hydrophyllium; the upper part is the proximal border. The axis of the future *Agalma* is thought to pass lengthwise through the float, and to cut also that pole of the yolk at which the polypite is forming.

The axis of the larva, as thus indicated, does not coincide with that which originally passes through the egg from the point at which the first elevation of epiblastic and hypoblastic layers took place to the opposite pole. It is apparently at right angles to this. If I am right in regard to the relationship, or, to use a stronger word still, the coincidence, of the former axis with the first plane of cleavage in the unsegmented ovum, the axis of the adult *Agalma* is at right angles to the first plane of cleavage. It may be mentioned at this point, that in the gonophore, as the egg first forms, the axis of the ovum passing through the red pole and the point of attachment of the gonophore is normally at right angles to the axis of the *Agalma*. The horizontal diameter of the larva at this stage is .70 mm. The vertical diameter is .75 mm. The longer axis of the ovum is .45 mm.; the shorter, .35 mm.

Fig. 1, Pl. IV. is taken from a larva a little older than the last, but still five days old. It resembles the young *Agalma Sarsii* at the close of the second week. The axis is placed vertical in the same position as that of the adult as usually represented. The separation of the hypoblast from the yolk-cells has left a cavity of relatively considerable size at the point where the polypite has begun to form. This cavity recalls a similar cavity in the larva of *Crystallodes* as figured by Hæckel. There is as yet no apparent diminution in the size of the primitive hydrophyllium, and the outlines of the epiblastic cells upon it can be easily traced. The yolk-cells still enclose the protoplasmic network, and have the same polygonal shape as earlier in their history. The float is more elongated and lies on one side of the yolk. It is filled

even in this larva with air or gas. Below it is a mass of reddish pigment concentrated in a cluster. The size of this larva is about the same as that of the last.

On August 13, seven days after the *Agalma* had been placed in the water, I was surprised to see, on looking for my larvæ through the walls of the glass vessel in which they were confined, that they had very much decreased in numbers. This led to the discovery that, whereas up to about this date they were found at all depths in the water, the larvæ are now to be seen only upon the surface. They often cluster together there, and the size of the float imparts to them a silvery color, like a small bubble of air resting on the water. The reason why the larvæ seek the surface at this phase of their development probably is, that the float has grown so large, or that the size of the primitive hydrophyllium has diminished. Whatever may be the cause which led the *Agalmata* to come to the surface, an effect which can probably be ascribed to the two causes mentioned above combined, we find that the size and general outlines of the first-formed covering-scale have undergone several modifications. Fig. 5, Pl. IV. shows a larval stage taken August 13th, in which the size of the scale is much smaller than in the larvæ already described. It is found at this time in the life of the larva that the border of the covering-scale has a tendency to draw together, and its surface becomes grooved or furrowed. In Fig. 6 we see a continuation of the same process, and in Fig. 7 still more reduction in the size of this body. One or two structural features have led me to regard the flat angular body on the yolk of these larvæ as the primitive hydrophyllium reduced in size. The tube which is found in the primitive scale, especially at the marginal termination, has a yellow color with black dots. These figments were found in the tube of the more reduced scale in its present condition. The small nuclei spread over the surface of the primitive hydrophyllium, called in our above description the nuclei of the epiblast, are easily recognized on the surface of the modified scale. With the reduction in external form of the plump walls of the first-formed scale, or primitive hydrophyllium, there has taken place also a change of form in its internal cavity. At the distal border of a scale represented in Pl. IV. fig. 8, the tube of the scale has bifurcated and extends in two divisions to the bell rim, where both end in the neighborhood of clusters of large nematocysts or lasso-cells. A yellow color was observed at these points, although the tube of the scale throughout most of its course is not as markedly colored. The small cell-like spots which appear on the surface of the scale and

resemble the nuclei of the epiblast as already described, are well marked on the ridges of the scale.

I have been unable to identify a scale of this kind with any of those figured in the larval stages of *Agalma* as described by Metschnikoff. Hæckel, however, figures a similar scale with divided tube in *Crystallodes*, but from his descriptions it does not follow that he regards it as the modified primitive scale. In *Physophora*, however, we find an approximation in shape to this scale in the primitive hydrophyllium, and moreover in this genus, as in mine, there is a smaller tube extending from the cavity of the scale to the surface, and ending in or near clusters of lasso-cells superficially placed. If the first-formed scales (primitive hydrophyllia) in both *Physophora* and *Agalma* are homologous, we may find the smaller bifurcations connecting the cavity of the scale in *Agalma* with its surface to be the same as the similar structures described by Hæckel in the young *Physophora*, provided, of course, that the flat scale of Fig. 8 is the modified primitive covering-scale of Pl. III. fig. 14. The flat scale (fig. 8) is certainly different in the contour and course of the central tube from the serrated hydrophyllia, and no other structure is thought of to which to refer it except the primitive hydrophyllium, that large covering-scale whose origin dates back into the youngest stages of the larva. What has already been here written of the modifications in form which the first-formed covering-scales go through, does not of course show that in the end it may not be simply cast off. My studies throw no light on this point. If it is ultimately dropped it undergoes modifications in outline before the consummation of that event.

CAMBRIDGE, July, 1885.

EXPLANATION OF THE PLATES.

br.	Bridge connecting two segmentation spheres.
cav.	Cavity.
cl. pl.	Cleavage plane.
1 *cl. pl.*	First cleavage plane.
2 *cl. pl.*	Second cleavage plane.
3 *cl. pl.*	Third cleavage plane.
c. p. l.	Cavity of primitive larva.
dm.	Thickening of the superficial layer.
eb.	Epiblast.
et.	Undivided portion of ovum.
fil.	Filament.
goph.	Gonophore.
gt.	Oil globule.
hb.	Hypoblast.
hyph.	Hydrophyllium.
m.	Membrane.
mb.	Mesoblast.
n.	Nucleus.
nl.	Nucleolus.
ovn.	Ovum.
pg.	Polar globule ?
pig.	Pigment spot.
pr.	Primitive furrow.
pr. hyph.	Primitive hydrophyllium.
pn. cy. / *py. cy.*	Pneumatocyst.
pn. ph.	Pneumatophore.
pyt.	Polypite.
r. pol.	Rosy pole, when not indicated, upper pole of figure.
r. tb.	Radial tube.
se.	Secondary furrow.
ser. hyph.	Serrated hydrophyllium.
1 *ser. hyph.*	First serrated hydrophyllium.
2 *ser. hyph.*	Second serrated hydrophyllium.
tb.	Tube.
ubr.	Umbrella.
vel.	Velum.
vt.	Vitellus.

vt. c. Vitelline cells forming a "protoplasmic network" through the yolk contents. In many of the figures only a few of these cells are drawn. They are found throughout the whole contents of the egg.

y. Unknown body, possibly remnant of membrane which encloses the egg.

All the figures, with the exception of Pl. IV. figs. 3–7, were drawn by the author with an Oberhäuser camera, objective B. B., eye-piece 2, Zeiss. Size reduced one half in photography. All figures except Pl. II. fig. 2 were drawn from living eggs and larvæ. The last mentioned was treated with dilute acetic acid before drawing.

PLATE I.

Fig. 1. Immature female gonophore with egg in the interior. Nucleus and nucleolus shown through its walls. Attached to parent.

" 2. Egg in a small immature gonophore, with sinuses between ovum and bell walls of gonophore.

" 3. Female gonophore found free in water. Enclosed ovum .5 mm. in diameter.

" 4. The ovum in the act of escape from the gonophore.

" 5. Ovum removed from a gonophore (artificially).

" 6. Ovum just escaped from gonophore (naturally), .45 mm. in diameter.

" 7. Egg showing the formation of a primitive furrow at one pole.

" 8. The same, ten minutes older than last.

" 9. The same, fifteen minutes older.

" 10. The same, twenty minutes older.

" 11. The same, twenty-five minutes older.

" 12. The same in two-cell stage, thirty minutes older than Fig. 7. Diameter .35 mm. The egg traced from Figs. 7–12 is .1 mm. smaller than that from Fig. 13 on.

" 13. Two-cell stage with beginning of a secondary furrow (*se.*), .60 mm. in long diameter, .43 mm. in least diameter.

" 14. Two-cell stage, ten minutes older than Fig. 13. .60 mm. in diameter.

" 15. The same, fifteen minutes older.

" 16. The same, eighteen minutes older.

" 17. The same, twenty minutes older.

" 18. The same, twenty-five minutes older, showing the formation of the secondary furrow, extending in a horizontal direction over the surface of the ovum. It also shows the deviation of the primary cleavage plane (1 *cl. pl.*) from a straight line when seen in profile.

" 19. Formation of a 4-cell stage by the closing in of the secondary furrow (*sc.*). The furrow is still open at each end. Thirty minutes older than Fig. 13, .50 mm. in diameter.

" 20. Four-cell stage, thirty-five minutes after Fig. 13.

" 21. The same, forty-five minutes after.

" 22. The same, fifty-five minutes after.

" 23. The same, one hour and ten minutes after.

PLATE II.

Fig. 1. Four-cell stage, two hours after Pl. I. fig. 13.
" 2. The same, two hours and five minutes after.
" 3. Segmented ovum showing the beginning of the tertiary furrow (3 *cl. pl.*), two hours and fifteen minutes older than that represented in Pl. I. fig. 13.
" 4. Four-cell stage, two hours and twenty minutes older.
" 5. The same, two hours and twenty-five minutes older.
" 6. Older stage, two hours and thirty minutes after Fig. 13. .50 mm. in diameter.
" 7. Segmented ovum, two hours and forty minutes older than Fig. 13.
" 8. Superficial granular layer (*dm.*) formed on the segmented ovum. Planula? .45 mm. in diameter.

PLATE III.

Fig. 1. Segmented egg with a marked increase of thickness of superficial layer at *dm.* .54 mm. in diameter.
" 2. The same, treated with acetic acid (two layers at pole, *cb.*, *hb.*).
" 3. An older egg, in which the thickness of the two layers is more marked. .60 mm. in greatest diameter.
" 4. The same, older.
" 5. The same, still older, showing the cavity of the primitive larva (*c. p. l.*).
" 6. A portion of the egg and the growing protuberance at its pole.
" 7. The same, older.
" 8. An older larva, with constriction between the scale and the surface of the ovum.
" 9. The same, older. The right side of this figure corresponds with the left of preceding and following figures, except in Fig. 12.
" 10. Embryo of about the same age as the last, reversed.
" 11. Embryo found in water, August 8 (adult put in August 6), a little older than the last.
" 12. Embryo still older.
" 13. The same, older, .47 mm. in diameter.
" 14. A primitive larva taken on the third day after the capture of the adult (72 hours old?), .70 mm. in diameter.
" 15. A larva a little older than the last, seen from the pole opposite that on which the primitive hydrophyllium is formed. The larval appendages are therefore for the most part seen through the yolk.
" 16. A larva so placed that the axis of the future *Agalma* is almost vertical. The union of the primitive hydrophyllium and the yolk is on the side of the yolk turned away from the observer. Older than last.

PLATE IV.

In none of the figures are the vitelline cells and the nuclei of the thin epiblastic layer of the primitive hydrophyllium brought out with sufficient distinctness. There should be two layers instead of one at *pyt.* in Figs. 1, 2, and 3.

In Figs. 2 and 4 the wall of *c. p. l.* is too black, and does not show the thickness of the hypoblast. The rows of nematocysts on the surface of *hyph.*, Fig. 8, are not well shown. The clusters of nematocysts at the margin of *hyph.* after the bifurcation of *tb.* are faulty. The cilia on the surface of the ovum, well seen in Fig. 2 at *pyt.* in my drawing, are not found in the photographic reproduction.

Fig. 1. A larva (primitive larva) in about the same age as the last and in a like position, except that the primitive covering-scale or hydrophyllium is turned a little more to the plane of the observer.

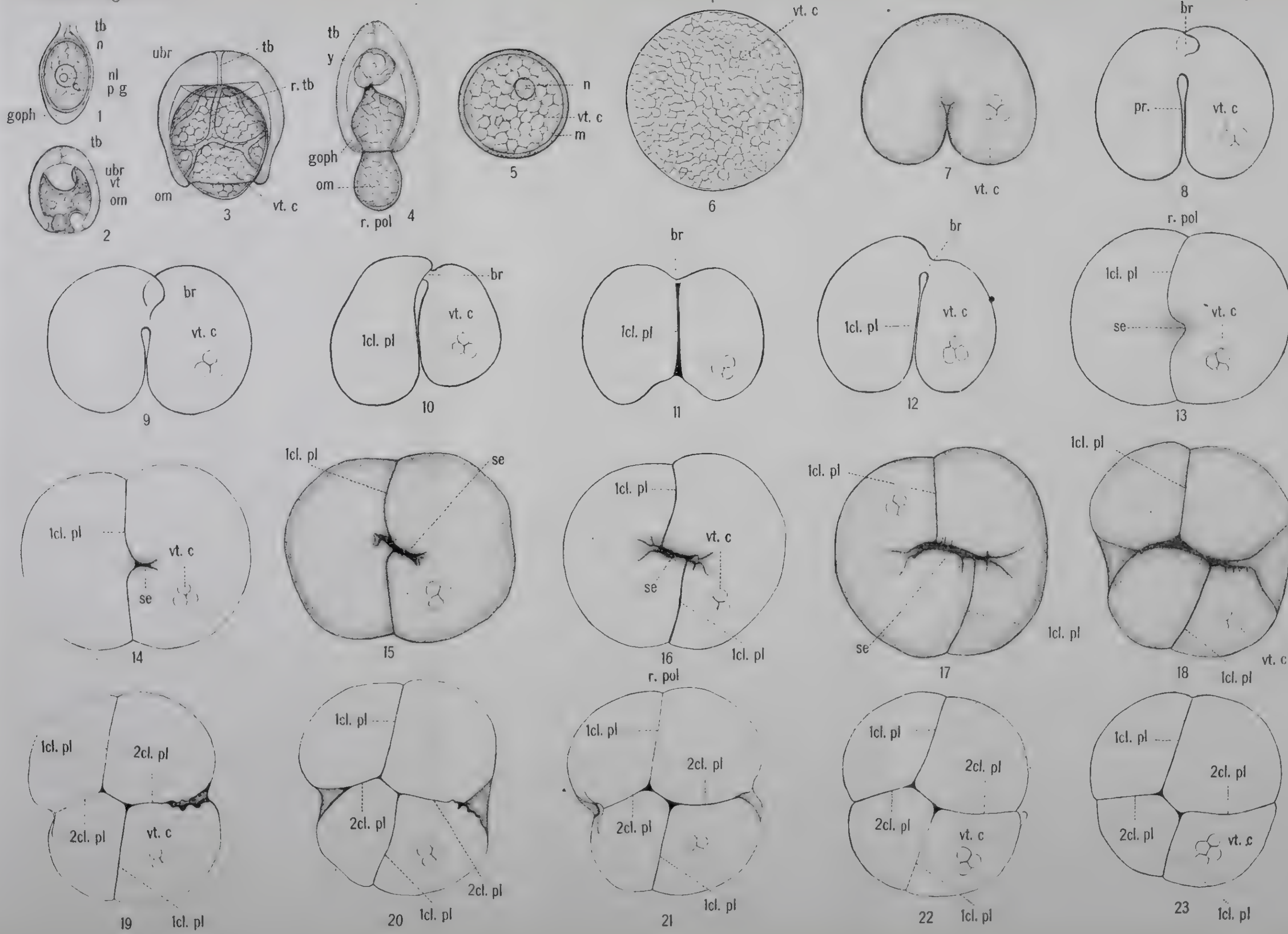
" 2. The same, looking through the primitive covering-scale upon the apex of the float, which lies in the geometric centre of the figure. Three days old.

" 3. Older larva, free-hand drawing, showing growth of serrated scale (*ser. hyph.*).

" 4. The same, lateral view.

" 5–7. Successive stages, in reduction in size of the primitive hydrophyllium, following its great development.

" 8. A larval *Agalma*, one week old, bearing a large flat hydrophyllium (remnant of the primitive covering-scale) through which runs a tube (*tb.*) which bifurcates and ends at the distal edge in clusters of nematocysts.



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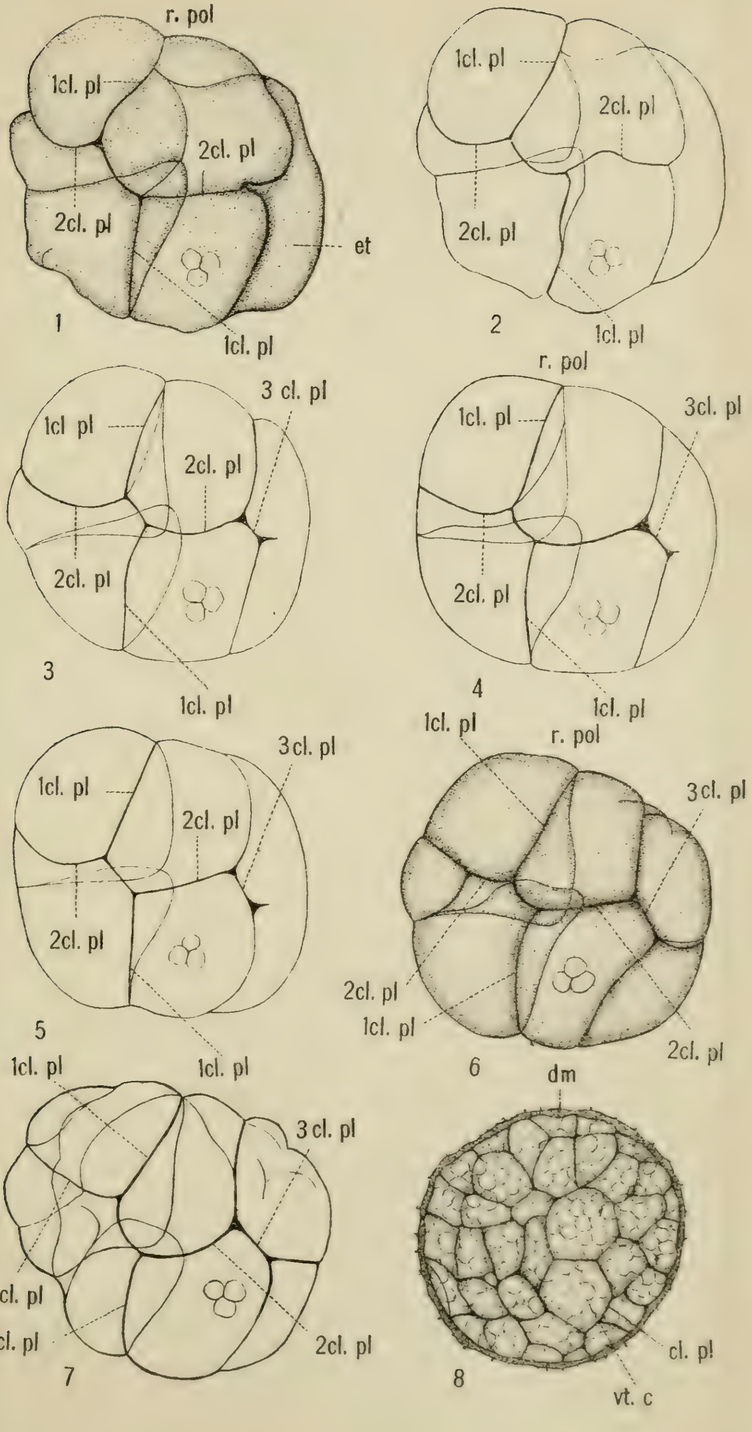
Fewkes, Agalma. Pl. II.



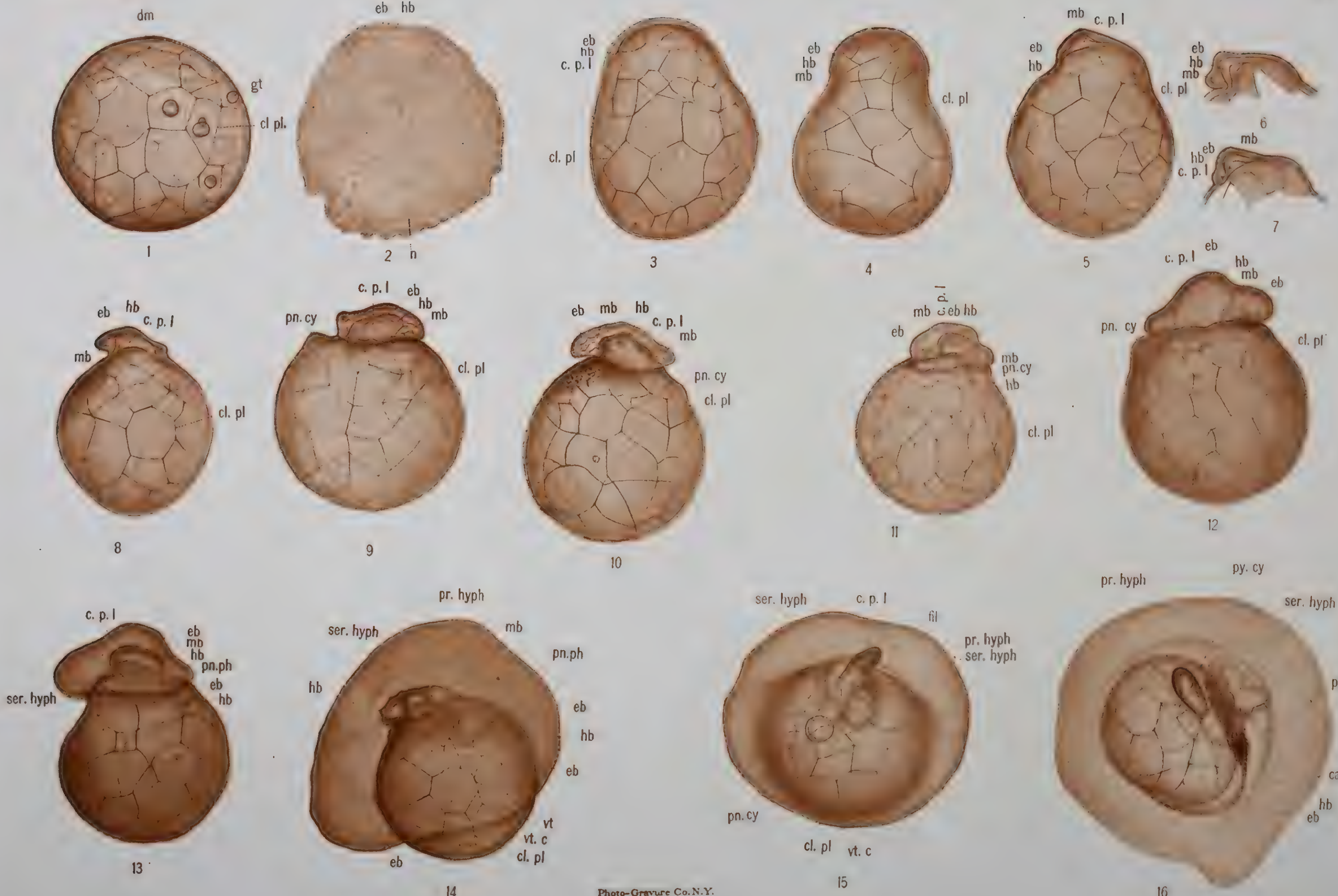
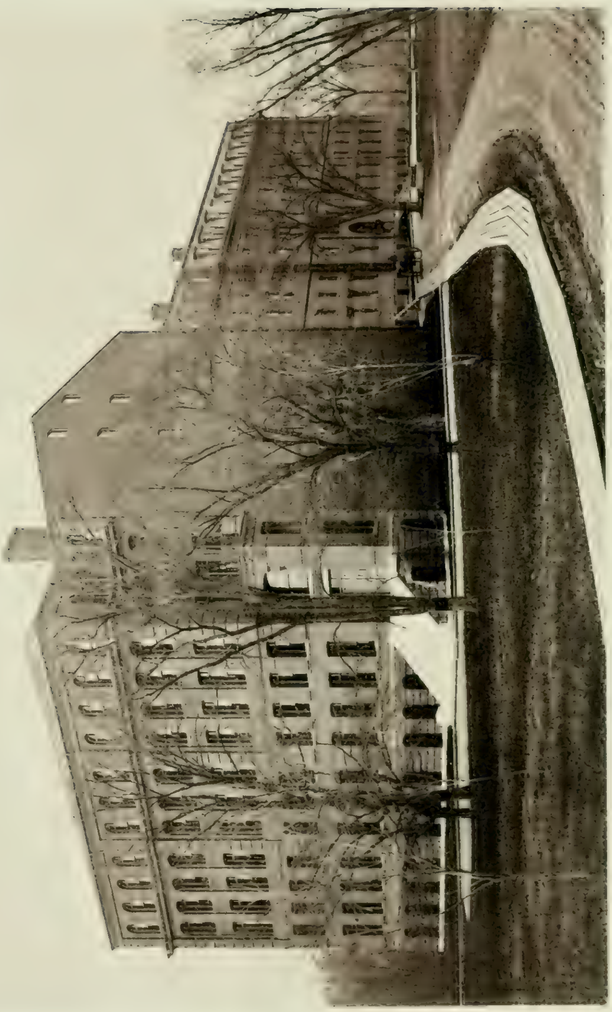


Photo-Gravure Co. N.Y.

Fewkes, Agalma. Pl. IV.

Photo-Gravure Co. N.Y.



ANNUAL REPORT

OF

THE CURATOR

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT HARVARD COLLEGE,

TO THE

PRESIDENT AND FELLOWS OF HARVARD COLLEGE,

FOR

1882–83.

CAMBRIDGE:
UNIVERSITY PRESS: JOHN WILSON AND SON.
1883.

FACULTY OF THE MUSEUM.

CHARLES W. ELIOT, *President.*

ALEXANDER AGASSIZ, *Curator.*

JOSIAH D. WHITNEY, *Secretary.*

THEODORE LYMAN.

GEORGE L. GOODALE.

OFFICERS.

ALEXANDER AGASSIZ	*Curator.*
JOSIAH D. WHITNEY	*Sturgis-Hooper Professor of Geology.*
HERMANN A. HAGEN	*Professor of Entomology.*
NATHANIEL S. SHALER	*Professor of Palæontology.*
WALTER FAXON	*Assistant Professor of Zoölogy.*
E. L. MARK	*Assistant Professor of Zoölogy.*
THEODORE LYMAN	*Assistant in Zoölogy.*
CHARLES E. HAMLIN	*Assistant in Conchology and Palæontology.*
JOEL ASAPH ALLEN	*Assistant in Ornithology.*
W. M. DAVIS	*Assistant in Geological Laboratory.*
SAMUEL GARMAN	*Assistant in Herpetology and Ichthyology.*
M. E. WADSWORTH	*Assistant in Lithology.*
J. W. FEWKES	*Assistant in charge of Radiates.*
C. O. WHITMAN	*Assistant in Zoölogy.*
PAULUS ROETTER	*Artist.*
MISS F. M. SLACK	*Librarian.*

REPORT.

To the President and Fellows of Harvard College:—

I have the pleasure of reporting that during the past year the latest addition to the Museum building has been completed. The transfer of the students to their new quarters has been effected, and the whole building is now occupied as originally planned. The rooms in this addition are devoted mainly to Laboratories, to the Library, Lecture-Room, and Curator's Room, only such space being reserved for exhibition as was necessary to connect the general exhibition-rooms with those of the main body of the building, hereafter to be erected.

Ten years wanting only a few weeks have passed since the care of the Museum devolved upon me. Some account is due here of the work done during that decade, and of the present state of the Museum as compared with its condition at the close of 1873. At that time, and indeed far earlier, from the very beginning of the institution, the general plan was sketched out in the mind of its founder. But the difficulties involved in the initiation of so large an undertaking prevented Professor Agassiz from developing his schemes. From want of rooms and of means for proper distribution, the immense accessions constantly accumulating upon his hands invaded, little by little, the space devoted to special objects. It became evident, at the time of his death, that nothing short of a radical rearrangement of the collections could bring out his plans and give them distinct expression. This rearrangement has been completed only within the past year, and no sign of the former confusion, due to a too rapid accumulation of material, is left.

At the close of 1873 the Museum building covered about 9,400 square feet of ground, and was filled to overflowing, from attic to basement, with the collections brought together by its first Director. The buildings and collections then represented an expenditure of about $200,000. From that time to the past

Academic year the new buildings and collections represent an additional expenditure of more than $500,000, in addition to the current expenditure. The ground covered by the additional building measures about 9,500 square feet. The resources at the disposal of the Director in 1873 came from the income of invested funds amounting to about $185,000. At the present moment, these amount to over $580,000. Ten years ago our departmental Library numbered some 5,000 volumes. Since that time it has increased to 16,000 volumes.

The temporary quarters provided for the instruction then given at the Museum afforded no facilities for the more accurate work now required in many branches of the Biological and Geological Departments. Although our present laboratories, still in their first year of service, are not equipped as I hope to see them, they afford even now ample facilities for instruction and investigation, as compared with those heretofore available at Cambridge.

The publications of the Museum, giving the results of investigations by specialists or by Assistants of the Museum, the materials for which have been drawn from our collections, have been rapidly issued. Volumes IV. to X. of the Bulletins, and Volumes IV. to IX. of the Memoirs, have been published during the last ten years.

Already, in 1853, the late Edward Forbes saw the importance of geographical displays as applied to the geological structure and products of the colonies of Great Britain, in connection with the Jermyn Street Museum of Practical Geology. He protested against the simple and single systematic arrangement, as not covering the ground necessary to make the Museum practically useful. He further dwelt on the fact, that a museum as such, not connected with an educational institution, was of very little use to the public beyond its value as a cyclopædia of reference.

We have attempted to build up an institution of that kind, and under our present conditions it is now possible to form some idea of the success of the Museum of Comparative Zoölogy, based as it is upon a plan essentially different from that of other like institutions. Our Exhibition Rooms, for instance, are comparatively small, each one devoted to a special subject, but so combined that, when taken together, they illustrate the animal kingdom as a whole in its general relations, and in its geographical and palæontological range and distribution. They are intended not only to

meet the wants of the public at large, and of beginners as well as of more advanced university students, but also to promote research by giving assistance to specialists and original investigators. Meanwhile, the work of the Museum proper should be in charge of Assistants whose duties are so arranged as to leave a good part of their time free for original research; the Museum as a whole forming an important branch of the Natural History Department of the University, with which its Assistants and Professors are intimately connected.

An enumeration of the contents and uses to which our space is devoted will give a better idea of our aims than a lengthy description.

EXHIBITION ROOMS.

Synoptic Room: —

Synopsis of the Animal Kingdom, living and fossil.

Five Systematic Rooms: —

Mammalia.

Birds.

Fishes.

Mollusca.

Radiates and Protozoa.

And their Galleries for the Systematic Collections of Reptiles, Insects, and Crustacea.

Seven Faunal Rooms and Galleries: —

North American.

South American.

African, including Madagascar.

Indian.

Australian.

* Europeo-Siberian.

* Atlantic.

* Pacific.

Four Rooms for the Palæontological Collections.

Two Rooms for the Palæozoic, one for the Mesozoic, and one for the Tertiary: —

* The Silurian and Devonian.

* The Carboniferous and Jura.

* The Cretaceous.

* The Tertiary.

* Not yet opened to the public.

The Work Rooms for the assistants of the Museum, and the Storage Rooms, which are also intended as work rooms of their special subjects, are distributed as follows, in addition to a large Receiving Room and a general workshop.

The Alcoholic Collections stored in the basement occupy: —

Four Rooms devoted to Fishes.

Two Rooms for Fishes and Reptiles.

One Room for Birds and Mammals.

One Room for Mollusca.

One Room for Crustacea.

One Room for the other Invertebrates.

The Entomological Department is to occupy eventually four gallery rooms of the first story.

The Work Rooms and Storage Rooms of the fifth story are filled by collections occupying: —

Five Rooms devoted to Birds and Mammals; three for skins and eggs, and two for skeletons.

One Room for Crustacea.

One Room for Mollusca.

One Room for Fish and Reptile Skeletons.

One Room for the Collection of dry Invertebrates (Corals, Echinoderms, Sponges, etc.).

Two Rooms for Fossil Vertebrates exclusive of Fishes.

The remaining Palæontological Collections are crowded into four Work and Storage Rooms.

Two Work Rooms for the Geological and Lithological Department.

Four Rooms are devoted to the Library of the Museum, and one Room for the office of the Curator.

There are also: —

A large general Lecture Room.

Three Laboratories for Students in Biology.

Three Laboratories for Students in Geology and Palæontology, with two smaller private rooms for the Instructors.

With the Biological Laboratories will be connected also a large Room for an Aquarium for both fresh-water and marine animals, and another room for a Vivarium, both of which are in the basement of the building.

This will give us, in all, seventeen rooms devoted to the exhibition of collections for the public; ten work and storage rooms in the basement, for the Alcoholic Collections: thirteen work and storage rooms for the dry Zoölogical Collections; eight similar

rooms for the Palæontological and Geological Collections; and thirteen rooms devoted to the Laboratories, Lecture Rooms, and Library connected with the instruction given at the Museum. The arrangement being such that whenever any Departments, as, for instance, the Geological and Geographical, or the Anatomical, or any other, outgrow their present quarters, room can be made for them, by extensions of the building, for a long time to come, without interfering with the plans which have been carried out thus far.

In adopting a small unit for the size of our rooms (30 × 40 ft.), we deliberately abandoned all attempts at Exhibition Rooms imposing from their size. We have aimed only to place before the public such portions of our collections as shall become instructive; and in our storage and work rooms the appliances for storage aim at economy of space, and are intended, while they do not neglect the careful preservation of the Collections, to give to the Assistants and students the freest and quickest possible access to them.

During the past summer the following persons pursued their studies at my Newport laboratory: — Mr. Fewkes, one of the Museum Assistants, who devoted his time principally to embryological studies of Annelids, Messrs. Barnes and Tuttle of the Scientific School, and Miss E. A. Nunn, who devoted her time to the study of the earlier stages in the development of Brachyura. Prof. C. O. Whitman took up the study of the early stages of some of the many species of pelagic fish-eggs, so common at Newport; and he is preparing in connection with me a preliminary report on his work, some of which is in continuation of investigations on the early stages of the bony fishes, begun nearly twenty years ago.

The course in Biology, given by Professors Farlow and Faxon, was attended by two Seniors, seventeen Juniors, four Sophomores, and one special student. Mr. G. W. Perkins assisted Professors Farlow and Faxon in the laboratory work of the course.

In Advanced Zoölogy, the course of Professor Faxon was followed throughout the year by thirteen Seniors, four Juniors, and one Student from the Scientific School.

During the past Academic year lectures in General Zoölogy were given by Dr. Mark to 104 students, of whom 39 were

Seniors, 34 Juniors, 25 Sophomores, 2 Freshmen, 2 Unmatriculated, and 2 Scientific Students.

In Dr. Mark's course on Embryology, the lectures were attended by three fourth-year students of the Lawrence Scientific School. The laboratory work was pursued by the three students attending the lectures, and by another who had previously attended the same course. The work consisted largely in the investigation of special topics proposed by the instructor at the beginning of the year.

These studies have resulted in the production of the following papers: —

1. On the Development of Œcanthus niveus, and its Parasite, Teleas. By Howard Ayers. Mem. Bost. Soc. Nat. Hist., Vol. III. No. 8.

2. On the Development of the Posterior Fissure of the Spinal Cord, and the Reduction of the Central Canal, in the Pig. By William Barnes.

3. Notes on the Development of Phryganidæ. By William Patten.

4. The Relation of the External Meatus, Tympanum, and Eustachian Tube to the First Visceral Cleft. By Albert H. Tuttle, of Boston.

The papers of Messrs. Barnes and Tuttle are in press in the Proceedings of the American Academy of Arts and Sciences.

Professor Shaler and Mr. W. M. Davis gave the usual courses, as follows: —

In Physical Geography, attended by sixty students. (Mr. Davis.)

In Elementary Geology, with field-work, attended by one hundred and eighty-five students. (Prof. Shaler and Mr. Davis.)

A course in Advanced Geology, with field work, attended by twenty-five students. (Prof. Shaler and Mr. Davis.)

A course in Palæontology, attended by seven persons. (Prof. Shaler.)

Professor Whitney lectured twice a week on Applied Geology, throughout the year. He was assisted in this course by Dr. Wadsworth, who also gave a course of lectures on Advanced Lithology, and took charge of the instruction of a small class of special students in Microscopic Lithology.

About five hundred volumes have been added to the Library of the Museum during the past year.

A special list of the Museum publications during the last Academic year is given in Appendix A of this Report. They consist of four numbers of the Memoirs, and of fifteen numbers of the Bulletin. The publications issued elsewhere by several specialists, based mainly upon Museum materials, are mentioned in the special Reports of the Assistants of the Museum. The other publications of the Professors and Assistants of the Museum are noted in the Reports of the different Departments.

The larger number of the publications of the Museum are devoted to Reports on the collections made by the "Blake." These consist of: —

A Report on the Stalked Crinoids collected by the "Blake" in the Caribbean, by Mr. P. H. Carpenter. Bull. M. C. Z., X., No. 4. 16 pp. December, 1882.

A Preliminary Report on the Fishes of the "Blake," collected during the Summer of 1880, along the Atlantic Coast of the United States, by Prof. B. G. Goode and Dr. Tarlton H. Bean. Bull. M. C. Z., X., No. 5. 37 pp. April, 1883.

A Report on the Ophiuridæ of the "Blake," by Theodore Lyman. Bull. M. C. Z., X., No. 6. 50 pp. 8 plates. May, 1883.

A Preliminary Report on the Anthozoa, by Prof. A. E. Verrill. Bull. M. C. Z., XI., No. 1. 72 pp. 8 plates. July, 1883.

A Report on the Isopods, by Oscar Harger. Bull. M. C. Z. XI., No. 4. 14 pp. 4 plates. September, 1883.

In connection with the explorations of the Gulf Stream by the Coast Survey, a Report on the Medusæ of the Bermudas, by J. Walter Fewkes. 10 pp. 1 plate.

Vol. X. No. 3 of the Bulletin contains a paper by Dr. Harrison Allen on the Ethmoid Bone in the Mammalia. 27 pp. 7 plates. November, 1882.

Of the seventh volume, the first of the Geological Series, three numbers have been published: —

No. 8, a short paper by Prof. Lesquereux, On some Permian Fossil Plants from Colorado. 4 pp. October, 1882.

Nos. 9 and 10, by Mr. W. M. Davis: On the Triassic Traps and Sandstones of the Eastern United States. 59 pp. 3 plates.

On the Lower Helderberg Limestones east of the Catskills. 20 pp. 2 plates. January, 1883.

Professor Whitney has published the third and concluding part of the Climatic Changes, Vol. VII. No. 2, Part III. Mem. M. C. Z., pp. 265–394. October, 1882.

I have myself published the following: —

A short paper entitled, A Chapter in the History of the Gulf Stream. Bull. M. C. Z., XI., No. 2. 5 pp.

The First Part of a Memoir on the Porpitidæ and Velellidæ of the Gulf Stream. Mem. M. C. Z., Vol. VIII. No. 2. 16 pp. 12 plates.

Selections from Embryological Monographs, containing the Echinodermata. Vol. IX. No. 2, Mem. M. C. Z. 45 pp. 10 plates. July, 1882.

The First Part of the Report on the Echini of the "Blake." Vol. X. No. 1, Mem. M. C. Z. 126 pp. 32 plates. September, 1883.

I have in addition published in the Memoirs of the American Academy, June, 1883, Vol. X., a paper on the Tortugas and the Florida Reefs, 27 pp., 8 maps, 4 plates, from observations made while on the "Blake," and while engaged in studying the surface fauna of the Gulf Stream under the auspices of the Coast Survey.

The last volume of the Transactions of the Royal Society of London, contains a memoir by the late Prof. F. M. Balfour and Mr. W. N. Parker, on the structure and development of Lepidosteus, based upon material sent them from the Museum.

Some progress has been made in the arrangement of the Exhibition Rooms. The Indian, the African, and the Australian faunal collections are now accessible to the public, although they yet are far from complete. The Systematic Collection of Birds has undergone a final arrangement, and the storage rooms devoted to the Radiates, the collections of fish and reptile skeletons, and the Crustacea, are now filled with their respective collections.

Mr. Garman has continued the explorations made by him in previous years in the West, and he and his assistants have sent us valuable additions to our collections of Mammalian and Reptilian fossil remains. We have specially to thank the Secretary of War, the Hon. R. T. Lincoln, and the Secretary of the Interior, the Hon. H. M. Teller, for the letters of introduction they kindly sent for the use of Mr. Garman while in the Territories.

The principal collections purchased were received from Prof. H. A. Ward of Rochester, and Mr. E. Häberlein, who sent us a second collection of Solenhofen fossils. An extensive collection of fossil fishes for the Lower Carboniferous, brought together by Mr. Thomas Stock of Edinburgh, has also been purchased for the Museum.

I hope during the coming winter to be able to move the collections of fossils now stored in the attic to their final storage rooms, and to make a beginning in the arrangement of the Palæontological Collections intended for exhibition.

ALEXANDER AGASSIZ, *Curator*.

CAMBRIDGE, October 1, 1883.

REPORT ON THE GEOLOGICAL DEPARTMENT.

By Josiah D. Whitney, *Sturgis-Hooper Professor of Geology.*

During the year 1882–83 instruction was given in this department of the Museum as follows. The Sturgis-Hooper Professor lectured twice a week on Applied Geology throughout the year: that portion of the course relating to building-materials, however, was as usual given by Dr. Wadsworth. The audience consisted of one candidate for the degree of S. D., one special student, and several members of the Senior Class in the College. Dr. Wadsworth gave also a course of thirty lectures on Advanced Modern Lithology, to an audience of eight persons, teachers and special students in that branch. There were also four special students in Practical Microscopic Lithology. Two of the last-mentioned students worked for a portion of the year only; the others devoted the whole of the year, and nearly all their time, to this work, and one of them was engaged in the examination of a region to which he was specially assigned with a view to the publication of his results.

The Sturgis-Hooper Professor spent a small portion of the summer in the field in New Hampshire, Vermont, and New York, making observations preparatory to work to be done in the future, bearing on important points in the geology of this country. Dr. Wadsworth continued his work on the geology of the coast of New England north of Boston. Several localities were visited by the Sturgis-Hooper Professor and Dr. Wadsworth together, for the purpose of investigating points of importance connected with work now in process of publication.

The collections in the lithological department have been considerably enlarged by material collected in the course of the field-work mentioned above. The most important addition, however, was that of the rock specimens and microscopic slides purchased of Mr. Diller of the Assos Expedition, the same being the

materials used by him in the preparation of his thesis entitled "Contributions to the Geology of the Troad." The rock specimens are 600 in number; the slides, 547. A collection of 100 thin sections of typical rocks has been arranged, and descriptions of them written out for the use of students of lithology.

The third part of the "Climatic Changes of Later Geological Times" was issued just after the publication of the last Annual Report of the Museum. That completes the seventh volume of the Memoirs. Most of the time of the Sturgis-Hooper Professor has been given to the preparation and putting into type of a paper entitled "The Azoic System and its Subdivisions." This paper is one of considerable length, and will complete the first volume of the Geological Series of the Bulletin. It is the joint work of Dr. Wadsworth and the Sturgis-Hooper Professor, and contains a pretty exhaustive and critical review of nearly all that has been published in this country with reference to the older crystalline rocks. This paper is not quite all in type, but can soon be completed and issued.

Dr. Wadsworth has also continued the preparation of his work on the Cordilleras rocks, intended to form the eleventh volume of the Memoirs of the Museum. The first portion of this might already have been issued, had not unaccountable delay in the engraving of the plates taken place. He has also published numerous shorter contributions to geology and lithology, the number of these being between fifty and sixty. Most of these are to be found in the Proceedings of the Boston Natural History Society, the American Journal of Science, or in the weekly publication entitled "Science." The titles of several of these are annexed, in order that their scope may be understood.

1. Meteoric and Terrestrial Rocks. Science, I. 127.
2. Keweenaw Point Geology. Ibid., 248.
3. St. David's Rocks and Universal Law. Ibid., 541.
4. The Microscopic Evidence of a Lost Continent. Ibid., 590.
5. Ocean Water and Bottoms. Ibid., II. 41.
6. The Argillite and Conglomerate of the Boston Basin. Bost. Proc. Soc. Nat. Hist., XXII. 130.
7. Some Instances of Atmospheric Action on Sandstone. Ibid., 202.
8. The Bishopville and Waterville Metorites. Am. Jour. Sci, (3,) XXXI. 32.

REPORT ON PALÆONTOLOGY.

By Prof. N. S. Shaler.

The following courses of instruction in Geology and Palæontology were given by myself and my associate, Mr. W. M. Davis, in the Academic year 1882–83.

1. (N. H. 1.) A Course on Physical Geography and Meteorology, attended by sixty students. This course was given by Mr. Davis.

2. (N. H. 4.) A Course in Elementary Geology, with optional field-work, attended by one hundred and eighty-five students. By N. S. Shaler and Mr. Davis.

3. (N. H. 8.) A Course in Advanced Geology, open only to those who have taken N. H. 4, attended by twenty-five students. In this course the lectures were given by N. S. Shaler, and the field-work, which is required from all students, was given by Mr. Davis.

4. (N. H. 14.) A Course in Palæontology, with study of specimens in the Museum cabinets, attended by seven persons. Given by N. S. Shaler.

5. (N. H. 16.) A course in advanced field-work, designed to fit students for practical geological surveying, attended by one student.

During the winter two sets of special meetings for discussion, one in the department of Geology and one in that of Palæontology, were held: — the former under the joint direction of Messrs. Shaler and Davis, the latter under the direction of Mr. Shaler. These meetings were well attended, and proved very useful parts of the instruction.

My absence during the preceding Academic year resulted in a great diminution in the numbers of students in the course in Elementary Geology; this accounts for the great reduction in numbers in the higher courses, which are fed from the men who take that course. In the Academic year 1883–84, the higher courses will be well attended. N. H. 8 (Advanced Geology) will have

fifty students; N. H. 14 (Palæontology), ten students; N. H. 15 (Historic Geology), four students; N. H. 16 (Field-work), eight students.

The students in the higher courses necessarily demand much labor on the part of the instructors. There is great need of an additional instructor in this department, who should have charge of the students' cabinet, and take a share in the field instruction, especially in the courses in Palæontology.

A considerable part of the time of the instructors in this department has been given to the study of the geological ground accessible for the purpose of field teaching. This is a necessary work, and one demanding much labor. From its results it appears that within fifty miles of Boston ground may be selected which will illustrate many important problems in the practical study of Geology. Nine students have been provided with summer work in the field. Two of these are engaged on the Northern Transcontinental Survey; three are studying classic localities in Europe; the others are at work at various points in this country. At present, this summer teaching is only given to those who have pursued the preliminary work in the College Classes.

I have published the following papers during the past Academic year: —

Vol. V. Reports of Kentucky Geological Survey. N. S. S. and assistants.

On the Knees of Taxodium distichum. Memoirs Kentucky Geological Survey.

On the original Connection of the Eastern and Western Coal-fields of the Ohio Valley. Memoirs Kentucky Geological Survey.

On the Age of the Caves in Lee County, Virginia. Memoirs Kentucky Geological Survey.

On the Floods of the Ohio Valley. Atlantic Monthly.

On the Improvement of the Pasture Lands of the Western Plains. Science.

The papers published by Mr. W. M. Davis, during the past year, exclusive of two in the Museum Bulletin, are: —

1. Glacial Erosion. Proc. Bost. Soc. Nat. Hist., XXII., 1882, pp. 19–58.

2. Brief Notice of Observations on the Triassic Trap Rocks of Massachusetts, Connecticut, and New Jersey. Amer. Journ. Sci., XXIV., 1882, pp. 345–349.

3. The Structural Value of the Trap Ridges of the Connecticut Valley. Proc. Bost. Soc. Nat. Hist., XXII., 1882, pp. 116–124.

4. The Deflective Effect of the Earth's Rotation. Van Nostrand's Engineering Magazine, XXVIII., 1883, pp. 297, 298.

5. An early Statement of the Deflective Effect of the Earth's Rotation. Science, I. 98.

6. The Origin of Cross Valleys. Science, I. 325.

REPORT ON MAMMALS AND BIRDS.

By J. A. Allen.

As the collections of Mammals and Birds for exhibition approach completeness, there is naturally a falling off in the number of specimens annually received, in consequence of the difficulty of getting the remaining desiderata. The additions during the last year are accordingly less numerous than for several years past. Of Mammals added, the stuffed specimens number thirty-three, and include, among the more noteworthy pieces, a fine musk-ox, and two Alaskan walruses, one an adult male, the other a very young example. The mounted specimens are eight in number, and include a killer-whale (*Orca*), and an Australian, a Chinaman, and a Sioux Indian. The other additions to the Mammals include a collection of eighteen skins (twelve species) and thirty-four skulls (fifteen species), from Orizaba, Mexico. The fin-backed whale (*Balænoptera musculus*), reported as procured in 1880 in the Report for 1879–80, is now mounted in the Systematic Room of Mammals, and forms a striking piece.

The additions to the collection of Birds embrace two hundred and seventy-five mounted specimens, one hundred and seventy-five skins, fifteen mounted skeletons, and a few skulls and sterna. Of the skins, one hundred are from Mexico, forty from California, and seventeen from the Island of Luzon, — the latter the gift of Mrs. Greenough. Mr. A. L. Babcock, of Sherborn, Mass., has presented eighteen skins and a few sterna.

The mounted material, both skins and skeletons, for the Systematic and Faunal Rooms, is now all on exhibition, except that for the European, Atlantic, and Pacific Rooms (not yet ready for use), and the Mammals are labelled. The preparation of the labels for the Birds has begun. There are still some species of both Mammals and Birds lacking to complete the South American

Room, a larger number still to finish the Indian Room, while one third or more of the desiderata for the African Room are yet to be added.

The collection of Fossil Mammals has been largely increased through Mr. Garman's highly successful explorations in the West, but the material has thus far been too slightly examined to admit of a detailed report.

The following papers have been published by Mr. J. A. Allen during the past year: —

1. On Trinominal Nomenclature. "Zoölogist," March, 1883.

2. Note on Increase in Size northward among North American Birds. Bulletin Nutt. Orn. Club, Vol. VIII. pp. 80–83.

3. Hybridity in Birds. "Ibis," April, 1883.

4. List of Birds observed in the Vicinity of Colorado Springs, Colorado. (Jointly with William Brewster.) Bulletin Nutt. Orn. Club, Vol. VIII. pp. 151–161, 189–198.

REPORT ON THE REPTILES AND FISHES.

By Samuel Garman.

The greatest additions to the collections of Reptiles and Fishes have been of Fossils. During a four months' expedition to the Tertiary, Cretaceous, and Jurassic formations of the West, the amount of material secured was quite large, while the discoveries made will occupy the parties left in the field for a year or more. From the Tertiary the receipts are principally mammalian remains, found under circumstances which afforded additional evidence of similarity in the modes of forming bone basins in the Pliocene, and bone licks or pockets in the Quaternary. The fishes from the Tertiary are in the main Clupeoids and Percoids; the reptiles, Turtles and Saurians. A much greater variety of fishes was obtained in the Cretaceous. Prominent among them are such genera as have been named *Portheus*, *Ichthyodectes*, *Erisichthe*, and various *Berycidæ*. Sauria, such as have been described under the names of *Liodon*, *Platecarpus*, *Clidastes*, etc., were plentiful. Six or seven species of Selachia, and various Pterodactyls and Birds, are also represented. From the Jurassic we have a number of the Dinosaurian Sauropoda, Ornithopoda, Stegosauria, and the like,— the most bulky and by far the heaviest of the accessions. On arrival, the majority of the fossils were found to be in good condition.

The largest single addition of recent species was a lot of thirty-five, purchased from the Linnæa Naturhistorisches Institut. Donations have been received from the Bergen Museum, Dr. C. O. Whitman, W. S. Bryant, J. A. Jeffries, N. Vickary, Dr. G. E. Manigault, Dr. B. G. Wilder, J. Ritchie, Jr., and George R. Allaman. Dr. Whitman presented some rare species from Japan. Professor Goode and Dr. Bean have identified and returned the fishes of the latest "Blake" Expeditions. A couple of shipments

of living turtles. lizards, and snakes were made to the Zoölogical Society of London.

In the Exhibition Rooms the principal work done has been in changing alcohol and labels, and in replacing poor specimens by better ones. A fine lot of mounted skeletons of fishes were prepared from alcoholic specimens for the Systematic Room. Changes in alcohol on account of coloration have been numerous, but the necessity has been proportionally much less than heretofore. For the Asiatic and the African Exhibition Rooms, the greater portion of the Reptiles and Batrachians have been mounted on tablets and placed on the shelves. The alcoholic Reptilia and Batrachia in storage have been moved to the room they are permanently to occupy, and are now being arranged. In the Skeleton Room, the material has been sorted, labelled, arranged, and — for the present — freed from insects.

The publications relating to the department include the following: —

On a Species of Pseudis from the Rio Arassuahy, Brazil.

On certain Reptiles from Brazil and Florida.

Introduction to the Reptiles and Batrachians of North America.

Synopses and Descriptions of the North American Ophidia.

A Systematic List and Synonymy of the Serpents of North America.

REPORT OF THE ENTOMOLOGICAL DEPARTMENT.

By H. A. Hagen.

The additions to the collection have been important, belonging mostly to the biology of insects. Prof. F. G. Schaupp, of Brooklyn, N. Y., presented to the Museum his whole collection of the previous stages of U. S. Coleoptera, together with the types and dissections figured and published in the Bulletin of the Brooklyn Entomological Society. Mr. S. H. Scudder presented a large lot of the previous stages of the U. S. Lepidoptera. Mr. J. A. Lintner, of Albany, N. Y., presented previous stages of U. S. Sphingidæ wanting in the collection. Prof. J. H. Comstock, of Ithaca, N. Y., presented a large lot of the types of the U. S. Coccidæ. A large lot of Cave Articulata from Prof. N. S. Shaler's Survey of Kentucky were sent to the Museum by Prof. A. S. Packard, Jr. Mr. S. Henshaw, Miss Cora A. Clark, Mr. Charles V. Riley, and Rev. A. E. Eaton, of England, presented valuable specimens. A full set of all stages of *Cosmosoma omphale*, prepared by Mr. Witfield, Florida, who is the first American to prepare biological specimens of American Lepidoptera for sale, was given by the Assistant.

The Library has been enlarged by some rare and costly works on Lepidoptera, by some rare older books, and by a large number of pamphlets and periodicals, by the Assistant.

The collection has been remarkably free from pests.

The numerous additions to the biological collection during the last years made a new arrangement unavoidable. Till now, 108 boxes are finished,—the Lepidoptera to the end of the Bombycidæ, and the Coleoptera to the end of Hydrophilidæ. Both proved to be three times larger than before. The work had to be postponed for the want of cabinets.

A large amount of spreading and setting insects was done by the lady assistant.

The following gentlemen have received materials for their publications from the Museum collection: —

Rev. A. E. Eaton, Croydon, England, for his Monograph of Ephemerina, of which 55 plates in quarto (advance sheets) are finished.

Mr. E. Simon, Paris, France, the Arthogastra of the collection, which have been returned determined. Publication in preparation.

Count Keyserling, Glogau, Silesia, the North American Spiders. Partly returned and published.

Dr. S. Meinert, Copenhagen, Denmark, all Myriopoda. Not yet returned.

Prof. H. J. Comstock, Ithaca, N. Y., Coccidæ. Published.

Prof. H. Osborn, Ames, Iowa, Aphidæ. Published.

Mr. S. Henshaw, the large collection of Coleoptera from Washington Territory. In way of publication.

The Assistant has published the Atropina family of a Monograph of the Psoridæ; the Papilio and Pieris of Washington Territory; a larger paper on the Colias of the United States; besides a number of smaller papers in American and European serials.

A number of special students have worked in the department from Ludington, Mich., Montreal, New York, Brooklyn, one during three months, the others several weeks.

Visitors to the department, students comparing the collection for determination, requests by letter for scientific information, and letters asking bibliographic questions, were as frequent as usual.

The following papers have been published by Dr. H. A. Hagen during the past year: —

1. *Jahresbericht fur* 1882, A. Dohrn and V. Caras. Neuroptera, Pseudoneuroptera.
2. *Stett. Ent. Zeit.*, pp. 225–332. Monographie der Psorinæ, Zweite Familie Atropina, mit histor. Anhang ueber die Todtenahr.
3. *Nature*, XXVII. 173. Invertebrate Casts.
4. *Ibid.*, XXVIII. 244. The Mealy Odorous Spot in Lepidoptera.

Entom. Monthl. Mag., London, Vols. XIX., XX.

5. The Tarsal and Antennal Characters of Psocidæ, p. 12.
6. A Marine Caddis-fly, p. 235.
7. Simulium feeding on Chrysalids, p. 254.
8. Insects from the East Coast of Greenland, p. 42.

Proceed. Boston Soc. Nat. Hist., Vols. XXI., XXII.

9. List of Papers by T. W. Harris, not mentioned in the Harris Correspondence, p. 150.
10. On Papilio Machaon, p. 105.
11. On Pieris, p. 134.
12. On the Genus Colias, pp. 150–178.

Boston Zoöl. Soc., Vol. II.

13. Notes on the American Badger, p. 29.

Papilio, New York, Vols. II., III.

14. Stretch Bombycidæ, p. 188.
15. On Papilio Machaon and its N. Am. Representatives, p. 149.
16. Necessary Restitution of the Names given by T. W. Harris to two N. Amer. Sphingidæ, p. 61.

Canadian Entomologist, Vols. XIV., XV.

17. The oldest Figures of N. Amer. Insects, p. 11.
18. Experiments with Yeast in destroying Insects, p. 39.
19. P. podalirius has Priority, p. 180.
20. Insects injurious to Fruit, by W. Saunders, XV., p. 117.
21. Trypeta Cerasi, p. 159.

REPORT ON THE CRUSTACEA.

By Walter Faxon.

Since last year's report valuable accessions to the collection have come by gift from Dr. H. A. Hagen, Prof. W. Kovalevsky, Dr. C. O. Whitman, Prof. L. A. Lee, Prof. R. Ramsay Wright, Mr. C. L. Herrick, Prof. A. S. Packard, Jr., and Mr. P. R. Uhler. Of these a collection of *Astaci*, comprising all the known species from Siberia and Amurland, presented by Prof. W. Kovalevsky, deserves especial notice. Exchanges have been made with the U. S. National Museum, Boston Society of Natural History, Peabody Academy of Science, and the Illinois State Laboratory of Natural History.

Professor Baird being desirous of sending a collection of United States Crayfishes to the London Fisheries Exposition, I identified for the National Museum a set made up from the material in both Museums, containing nearly every species described from this country.

For the loan of valuable material during the year I have to thank the Director of the U. S. National Museum, the Council of the Academy of Natural Sciences of Philadelphia, Mr. P. R. Uhler of Baltimore, Prof. A. S. Packard, Jr. of Providence, the Curators of the Boston Society of Natural History, and the Peabody Academy of Science, Salem, Prof. L. A. Lee of Brunswick, Me., Prof. S. A. Clarke of Williamstown, Mass., Prof. O. P. Hay of Irvington, Ind., and Prof. S. I. Smith of New Haven.

A portion of the "Blake" collections is still in the hands of Prof. A. Milne-Edwards, of Paris, and Prof. S. I. Smith, of New Haven. In his "Recueil de Figures de Crustacés nouveaux ou peu connus," 1er livr., Paris, April, 1883, the former has published figures of twenty-six of the remarkable species from these collections.

REPORT ON THE CONCHOLOGICAL AND PALÆONTOLOGICAL DEPARTMENTS.

By Charles E. Hamlin.

Two valuable additions to the Fossil Invertebrata of the Museum have been made during the year, the first being a second purchase from Ernst Häberlein of Pappenheim, Bavaria, consisting in part of species from the Lithographic Slate of Solenhofen, and partly of species from the beds of Kelheim, on the Danube. Besides the Invertebrata, this collection includes many fine fossil Fishes. The second is a collection of Gasteropoda, Lamellibranchiata, and Brachiopoda, chiefly the last, from the Bridgewater Limestone and other strata of Tasmania. To these are added admirably preserved Gasteropoda and Lamellibranchiata from the later Tertiary of Cape Schank, Victoria, S. E. Australia. The whole collection is in excellent condition, and is of especial interest as containing the first representatives of the palæontology of Australia and Tasmania that have come into the possession of the Museum, for which all have been expressly collected during several years past by Lieut. C. E. Beddome. In addition to the fossils, he has, after long and careful search, gathered and forwarded a collection of all papers and maps which have been published upon the geology of Tasmania, with the exception, as he states, of two papers no longer to be procured. The specimens and publications are received in exchange for recent shells.

The selection, identification, and mounting of recent and fossil Lamellibranchiata for exhibition have been completed, and the prepared series have been arranged, filling the cases of the Shell Room Gallery.

A partial suite of shells, 77 species, 206 specimens of generic types, has been prepared and delivered to the East Boston High School.

Several lots of shells have been named, for Oberlin College, Ohio, and for the private collections of H. K. Morrell, of Gardiner, Me., James N. Bishop, of Plainville, Conn., and Mrs. Wells, of Cambridge.

Considerable work has been done in the transfer and care of the collection of Fossil Plants, and in storing and labelling collections of Vertebrate Fossils as they have been received.

Some weeks have been occupied in naming and describing several small collections of fossil shells from Mount Lebanon, Syria, with a view to publication.

The exchanges of the year have been as follows: —

From Lieut. C. E. Beddome of Hobart, Tasmania, have been received 279 species, 1400 specimens, of recent marine shells of Tasmania.

From Count Emil Kornis, of Buda-Pesth, a lot of Hungarian Helices.

To Mr. O. N. Fearon have been sent, in return for Fossil Fishes from the Coal Measures of East Liverpool, Ohio, 57 species, 157 specimens, of recent Gasteropod shells.

To Mr. H. K. Morrell, of Gardiner, Me., and to Prof. L. A. Lee, of Bowdoin College, small lots of shells in exchange for other shells.

REPORT ON THE RADIATES.

By J. Walter Fewkes.

During the past year the whole collection of dry Corals and Sponges, together with the dry Starfishes and Echinoids, have been arranged in a room on the fifth floor in the new part of the Museum. The large collection of deep-sea bottoms, mostly those collected on the different "Blake" Expeditions, have been transferred to the same room. With these a collection of coral rocks and sands has also been placed.

The large collection of "Blake" Sponges identified by Schmidt, containing many types, has been divided. The dried specimens have been placed in the new room with the general collection of dried Sponges, while the alcoholic portion has been removed to the cellar.

The dried specimens of deep-sea Corals identified by Mr. Pourtalès have been placed with the general collection. My room in the new part of the Museum now contains, with the sea-bottoms, coral rocks, and a few corallines, most of the dried specimens of Sponges, Hydroids, Corals, and Echinoderms; while a room in the cellar of the old part will be devoted to alcoholic specimens of the same groups.

The rich collection of living Crinoids from the "Blake" Expeditions have been identified and added to the alcoholic Echinoderms. A list of localities from which specimens of these animals were taken has been published in a Museum Bulletin of the past year, supplemental to Mr. P. Herbert Carpenter's Report on the "Blake" Crinoids. Specimens of the different species mentioned in this list have been sent to several Museums. A representative collection of living Crinoids has been placed on exhibition in the South American Faunal Room, and in the general Exhibition Collection of Echinoderms.

Among the additions of the year are a number of specimens of Corals, identified by Professor Verrill, which have been received from the United States Fish Commission. The Museum at Bergen has sent a small identified collection of Radiates from the west coast of Norway.

An unidentified collection of "Blake" Worms and Bryozoa, a few specimens of pelagic Tunicata, with many deep-sea Alcyonoids, duplicates of the collection sent last year to Professor Verrill for identification, have been temporarily removed to the room now occupied by Mr. Agassiz.

The Museum published during the year the following papers, which had been prepared by me for the Bulletin: —

Explorations of the Surface Fauna of the Gulf Stream, under the Auspices of the United States Coast Survey, by A. Agassiz. — IV. On a Few Medusæ from the Bermudas. By J. Walter Fewkes. pp. 11, folded plate. Bull. Mus. Comp. Zoöl., Vol. XI. No. 3.

List of Additional Stations of Stalked Crinoids collected by the "Blake." Prepared by J. Walter Fewkes. pp. 2. Bull. Mus. Comp. Zoöl., Vol. X. No. 4. (Supplement.)

REPORT ON THE LIBRARY.

By Miss F. M. Slack.

During the year ending September 1, 1883, the Library has been increased by 576 volumes, 941 parts, and 651 pamphlets.

The whole number of volumes now in the Library of the Museum (exclusive of pamphlets) is 16,102.

[A.]

PUBLICATIONS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

FOR THE ACADEMIC YEAR 1882–83.

Of the Bulletin.

Vol. VII.

No. 8. On some Specimens of Permian Fossil Plants from Colorado. By Leo Lesquereux. 4 pp. October, 1882. 3 c.

No. 9. On the Relations of the Triassic Traps and Sandstones of the Eastern United States. By William Morris Davis. 59 pp. 3 Plates. January, 1883. 75 c.

No. 10. The Folded Helderberg Limestones east of the Catskills. By William Morris Davis. 20 pp. 2 Plates. January, 1883. 25 c.

No. 11. The Azoic System and its Subdivisions. By J. D. Whitney and M. E. Wordsworth, completing the volume (in press).

Vol. IX. completing the volume : —

No. 3. On a Revision of the Ethmoid Bone in the Mammalia. By Harrison Allen. 27 pp. 7 Plates. November, 1882. 75 c.

No. 4. Reports on the Results of Dredging by the U. S. C. S. Steamer "Blake." — XVIII. The Stalked Crinoids of the Caribbean Sea. By P. H. Carpenter. 16 pp. December, 1882. 15 c.

No. 5. Reports on the Results of Dredging by the U. S. C. S. Steamer "Blake." — XIX. Report on the Fishes. [East Coast of the U. S.] By G. Brown Goode and Tarleton H. Bean. 37 pp. April, 1883. 30 c.

No. 6. Reports on the Results of Dredging by the U. S. C. S. Steamer "Blake." — XX. Report on the Ophiuroidea. By Theodore Lyman. 50 pp. 8 Plates. May, 1888. $1.00.

Vol. XI.

No. 1. Reports on the Results of Dredging by the U. S. C. S. Steamer "Blake." — XXI. Report on the Anthozoa and on some Additional Species dredged by the "Blake" in 1878–79, and by the U. S. Fish Commission Steamer "Fish Hawk" in 1880–82. By A. E. Verrill. 72 pp. 8 Plates. July, 1883. $1.25.

No. 2. Reports on the Results of Dredging in the U. S. C. S. Steamer "Blake." — XXII. A Chapter in the History of the Gulf Stream. By Alexander Agassiz. 5 pp. May, 1883. 5 c.

No. 3. Exploration of the Surface Fauna of the Gulf Stream, under the Auspices of the U. S. Coast Survey. By Alexander Agassiz. — IV. On a few Medusæ from the Bermudas. By J. Walter Fewkes. 10 pp. 1 folding Plate. August, 1883. 20 c.

No. 4. Report on the Results of DREDGING by the U. S. C. S. Steamer "Blake." — XXIII. Report on the ISOPODA. By OSCAR HARGER. 13 pp. 4 Plates. September, 1883. 40 c.

Nos. 5 & 6. Supplement to the "Blake" CEPHALOPODS. By A. E. VERRILL. With 6 Plates. In press.

No. 8. Supplement to Vol. V. of N. A. TERRESTRIAL MOLLUSKS. By W. G. BINNEY. 2 Plates. In press.

(Vol XI. *to be continued*).

Of the Memoirs.

Vol. VII., completing the volume.

No. 2. The Climatic Changes of Later Geological Times. Part III. pp. 265–394. October, 1882. For sale. Apply to Prof. J. D. Whitney.

Vol. VIII., completing the volume.

No. 2. Exploration of the SURFACE FAUNA of the GULF STREAM under the Auspices of the U. S. Coast Survey. By ALEXANDER AGASSIZ. — III. Part I. The PORPITIDÆ and VELELLIDÆ. By ALEXANDER AGASSIZ. 16 pp. 12 Plates. $1.50.

No. 3. North American Reptiles. 200 pp. 9 Plates. By SAMUEL GARMAN, in Connection with the Kentucky Geological Survey, N. S. SHALER, Director. (In press.)

Vol. IX.

No. 2. Selections from Embryological Monographs, compiled by ALEXANDER AGASSIZ, WALTER FAXON, and E. L. MARK. — II. ECHINODERMATA. By ALEXANDER AGASSIZ. 45 pp. 15 Plates. July, 1883. $3.00.

(Vol. IX. *to be continued.*)

Vol. X.

No. 1. Reports on the Results of DREDGING by the U. S. C. S. Steamer "Blake." — XXIV. Part I. Report on the ECHINI. By ALEXANDER AGASSIZ. 126 pp. 32 Plates. September, 1883. $7.00.

(Vol X. *to be continued.*)

Also preparing: —

Illustrations of North American Marine Invertebrates, from Drawings by BURKHARDT, SONREL, and A. AGASSIZ, prepared under the Direction of L. AGASSIZ. Selections from Embryological Monographs, compiled by A. AGASSIZ, W. FAXON, and E. L. MARK. Papers by Prof. E. EHLERS on the Annelids of the Straits of Florida dredged by Messrs. POURTALÈS and AGASSIZ; in Connection with the Geological Survey of Kentucky, by Prof. N. S. SHALER on the Brachiopoda of the Ohio Valley; by A. HYATT, on Cephalopods; by W. G. Binney on N. A. Mollusca; by E. L. MARK on the Development of Arachnactis; by M. E. WADSWORTH; by J. W. FEWKES, on the Embryology of Annelids; and by A. AGASSIZ and C. O. WHITMAN, on the Embryology of Bony Fishes.

In Connection with Professor J. D. WHITNEY, the Water Birds of the United States. By BAIRD, BREWER and RIDGWAY.

Reports on the Dredging Operations in Charge of ALEXANDER AGASSIZ, by the U. S. Coast Survey Steamer "Blake," for 1877, 1878, 1879, and 1880. H. B. BRADY (Foraminifera), P. H. CARPENTER (Crinoidea), W. H. DALL (Mollusks of the Gulf of Mexico and the Caribbean Sea), G. B. GOODE and T. H. BEAN (East Coast Fishes, and Fishes of the Gulf of Mexico and the Caribbean Sea), C. E. HAMLIN (East Coast Mollusks), A. A. HUBRECHT (Nemerteans), A. MILNE-EDWARDS (Crustacea), J. MURRAY (Sea Bottoms), E. PERRIER (Starfishes), A. E. VERRILL (Alcyonaria), and H. THEEL (Holothuroidea).

[B.]

INVESTED FUNDS OF THE MUSEUM.

In the hands of the Treasurer of Harvard College, Sept. 1, 1883.

Sturgis-Hooper Fund	$100,000.00
Gray Fund	50,000.00
Agassiz Memorial Fund	297,933.10
Teachers & Pupils' Fund	7,594.01
Permanent Fund	117,469.34
Humboldt Fund	7,740.66
	$580,737.11

The payments on account of the Museum are made by the Bursar of Harvard College, on vouchers approved by the Curator. The accounts are annually examined by a committee of the Museum Faculty. The only funds the income of which is restricted, the Gray and the Humboldt Funds, are annually charged in an analysis of the accounts with vouchers to the payment of which the income is applicable.

The income of the Gray Fund can be applied to the purchase and maintenance of collections, but not for salaries.

The income of the Humboldt Fund can be applied for the benefit of one or more students of Natural History.

ANNUAL REPORT

OF

THE CURATOR

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT HARVARD COLLEGE,

TO THE

PRESIDENT AND FELLOWS OF HARVARD COLLEGE,

FOR

1883-84.

CAMBRIDGE:
UNIVERSITY PRESS: JOHN WILSON AND SON.
1884.

FACULTY OF THE MUSEUM.

CHARLES W. ELIOT, *President.*

ALEXANDER AGASSIZ, *Curator.*

JOSIAH D. WHITNEY, *Secretary.*

THEODORE LYMAN.

GEORGE L. GOODALE.

OFFICERS.

ALEXANDER AGASSIZ	*Curator.*
JOSIAH D. WHITNEY	*Sturgis-Hooper Professor of Geology.*
HERMANN A. HAGEN	*Professor of Entomology.*
NATHANIEL S. SHALER	*Professor of Palæontology.*
WILLIAM JAMES	*Assist. Prof. of Physiol. and Comp. Anat.*
WALTER FAXON	*Assist. Prof. of Zoölogy.*
E. L. MARK	*Assist. Prof. of Zoölogy.*
THEODORE LYMAN	*Assistant in Zoölogy.*
CHARLES E. HAMLIN	*Assistant in Conchology and Palæontology.*
D. D. SLADE	*Assistant in Osteology.*
JOEL ASAPH ALLEN	*Assistant in Ornithology.*
W. M. DAVIS	*Assistant in Geological Laboratory.*
SAMUEL GARMAN	*Assistant in Herpetology and Ichthyology.*
M. E. WADSWORTH	*Assistant in Lithology.*
J. W. FEWKES	*In charge of Radiates.*
C. O. WHITMAN	*Assistant in Zoölogy.*
PAULUS ROETTER	*Artist.*
MISS F. M. SLACK	*Librarian.*

REPORT.

To the President and Fellows of Harvard College: —

During the past year we have had the advantage of occupying our new quarters, and it is with no little satisfaction that I am able to report the complete success of the new organization. Our present facilities for the instruction of undergraduates, of advanced students, and of specialists, enable us to accomplish all that we expected. The additional room now at our command for our Library has greatly facilitated its care and final arrangement; the reading room is far in advance of our wants. The Museum is now so fully equipped that its business of caring for the collections and giving instruction in Natural History can be carried on to great advantage. With ordinary foresight, we shall never hereafter fall back into the confusion which was almost a necessary preliminary to the present order. The orderly condition of the different departments now depends entirely upon the heads of the various branches and upon the instructors.

The old roof has been changed to correspond to that of the later additions, and the rooms thus obtained will be used for the storage of the Vertebrate Fossils, the dry Mollusca, and the Crustacea. This arrangement will give excellent working-rooms for these three departments, and bring the collection of Vertebrate Fossils into close connection with that of Vertebrate Skeletons, which is stored in the adjoining rooms.

The following annual courses of instruction have been given at the Museum: —

A course in Biology, by Professors Farlow and Faxon.

A course in Cryptogamic Botany, by Professor Farlow.

An advanced course in Zoölogy, by Professor Faxon.

General Lectures were given by Dr. Mark, who also took charge of the new Embryological Laboratory, while Professor

Faxon took charge of the general Biological Laboratory, assisted by Mr. J. H. Perkins.

Professor Shaler and Mr. Davis gave the usual courses in Geology, Palæontology, and Physical Geography.

Prof. J. D. Whitney gave, as heretofore, a course in Economic Geology, Mr. Wadsworth assisting in a part of the course.

The publications embodying original work carried on in the different departments, or based upon Museum materials, will be found enumerated in the special Reports.

During the past summer the following persons pursued their studies at my Newport Laboratory: —

Mr. Fewkes, one of the Museum Assistants, devoted his time principally to the Embryology of Siphonophores.

Mrs. Whitman made good progress with her studies of the early stages of the Crab.

Professor C. O. Whitman assisted me in the continuation of my investigation upon the early stages of Fishes, commenced the previous year. A preliminary notice of this work has been published, "On the Development of some Pelagic Fish Eggs, by Alexander Agassiz and C. O. Whitman." (Proc. Am. Acad., XX., pp. 52, 1 pl., August, 1884.)

A special list of the Museum publications during the last Academic year is given in Appendix A of this Report. They consist of seven numbers of the Bulletin, and two numbers and two volumes of the Memoirs; the two complete volumes, on the Water Birds of North America, are in continuation of the publications of the California Geological Survey, in connection with Prof. J. D. Whitney.

About six hundred volumes have been added to the Library of the Museum during the past year.

Small collections of Vertebrate Fossils have been received from Wyoming and Kansas, but they have not yet been examined carefully enough to enable me to report upon their value.

A collection of alcoholic Invertebrates, destined for the Atlantic Exhibition Rooms, has been purchased from the Naples Zoölogical Station. It is in a remarkably perfect state of preservation.

We have also received from Professor Lesquereux the collection of fossil plants collected by Professor Lakes, principally in Colorado, which had been sent to him for study.

Among other noteworthy acquisitions, I may mention a fine Pterodactyle from Solenhofen.

The collection of North American Coleoptera bequeathed to the Museum by the late Dr. John L. Le Conte, has been sent to us by Mrs. Le Conte. Dr. George H. Horn, the life-long friend of Dr. Le Conte, was kind enough to superintend the packing and forwarding of this invaluable addition to our Entomological Department. He himself accompanied the collection to Cambridge, and we owe to his interest the excellent condition in which it has reached us.

The Europeo-Siberian Room is nearly ready for exhibition, and during the coming year the greater part of the faunal collections of the African Room will probably be sent to the Museum by Prof. H. A. Ward. The exhibition cases of the Atlantic Room have made good progress during the past year. It will be impossible to do anything towards the arrangement of the Palæontological Exhibition Rooms until the whole of our Palæontological collections have been unpacked and passed through a preliminary examination.

The Museum collections have, during the past year, supplied materials to several specialists. A large part of the Blake collections are still in the hands of the naturalists, who have kindly undertaken the preparation of the Zoölogical Reports. As fast as the collections are returned, they have been distributed to those museums in this country and in Europe which give special attention to the study of Marine Faunæ. The Echini and Ophiurans, and a part of the Crustacea, have been thus distributed.

In the light of past experience, I look with no small concern to the future growth of the Museum. As collections accumulate, additional room will be required for their storage, and new assistants for their care. The resources of the institution will surely soon be entirely inadequate for the maintenance of the Museum on the scale of its present growth, if the policy thus far pursued is continued. The future welfare of the establishment is secured by its permanent connection with the University. But its funds naturally share the cautious management of the College, and the present Director has seen the income of the Museum gradually diminish from $35,000 a year to about $25,000. Meanwhile the salaries of the assistants and other

employees have, with the greatest difficulty, been kept at about the same total as when our income was nearly one third larger. It is not to be expected that the public will take more than a very limited interest in the Museum, especially as in this vicinity there are no less than three Natural History establishments, all having very similar aims. With the present tendency to specialization, it seems impracticable to carry on an immense Natural History collection without a staff of specialists far greater in number than any institution not backed by government or by an immense endowment can ever hope to support. The present organization of the Museum is based upon the assumption that its resources will keep pace with the increased specialization of its different branches, and the attempt has been made to combine the work of assistants and that of original investigation. That officers' positions cannot be maintained except in connection with the permanently endowed Professorships of the University, is becoming self-evident. No University, even if it be a great centre for Natural History, can maintain more than a limited number of endowed chairs ; and if the professorial duties of their incumbents be not too arduous, a good amount of original work may be expected of them. Still, with the present tendency of science, original work cannot be based mainly upon the collections of a great museum. The geologist and the zoölogist must both supplement their work in the field. With the requirements of to-day, collections can only supply materials for investigations of limited scope ; and while undoubtedly many most interesting problems require large collections for their solution, the more important biological problems of the day require materials prepared for special purposes in the laboratories of the Universities. It is there that the influence of the teachers will be felt in the direction given to the work of their more advanced students, and it should be the province of a University to foster this work by granting special facilities for it, as well as for the publication of these investigations. This the Museum is now prepared to do.

Laboratories for Biology and Geology — in their most extended sense — have been erected for the University. They have now been occupied for a year, and their capacity for work depends entirely upon the means for their equipment placed

at the disposal of the various Professors connected with the Natural History departments, and upon the time they may have left from their professorial duties for original research. There is no department of the University which depends so little for its success upon the resources of the College, as the Natural History Department connected with the Museum. Beyond the salaries of the Professors and Instructors, there is practically nothing which is not provided for by the Museum in the way of work-rooms and laboratories. Their care, their heating, and the supply of the materials for the students, do not fall upon the University; by far the greater part of the current publications in Natural History have for some time past been purchased by the Museum, and the publications issued under the auspices of the Museum provide the means for making known any investigation carried on in its laboratories.

The museum assistant in charge of a special department must naturally, if the purpose for which large collections are brought together is carried out, spend the greater part of his time in preparing them for the specialist who is at some future time to avail himself of the treasures brought together for his benefit. There is, therefore, the same danger that an eminent specialist, after his appointment to the curatorship of a department of a great museum, will find his museum duties so arduous as to prevent him, as his colleague in the professorial chair has been prevented, by official work, from doing any original work.

The main point for us and other directors of museums connected with educational institutions is to settle upon a policy which will in the end best promote the growth of a school of Natural History, while fostering original research in the occupants of the professorial chairs and in the assistants of the various departments.

Since the foundation of this Museum the conditions for scientific research in this country have greatly changed. The general government has now undertaken, in connection with the United States Coast and Geodetic Survey, with the Geological Survey, with the National Museum, and with the United States Fish Commission, an amount of scientific investigation in various directions which makes it a mere waste of time for those not officially connected with these government establishments to undertake certain lines of work. Recognizing this, it becomes

at once apparent that it is a mere waste of time and money for us to continue accumulations of collections which will most certainly be duplicated at Washington or New York; and that, beyond a very limited appeal to the public in the collections placed on exhibition, we should expend our resources only in the direction of fostering such original work as may most efficiently be conducted by the Professors holding endowed chairs in our University. This can be best accomplished by a comparatively small museum staff, provided the assistants necessary for laboratory instruction are supplied to the teachers, and they find time from their teaching to use the materials of this institution as far as it is available. The function of a museum is without doubt to use its resources in the purchase and care of special collections, made by their owners at the cost of a great expenditure of time and money. Some of these collections, illustrating the past history of a district, frequently represent the work of a whole lifetime devoted by some specialist to a limited field, in which his collections have been brought to a great state of perfection; and in such collections the Museum is very rich in certain directions. I would name only the Dyer, Taylor, Gebhard, Day, and Walcott collections, among the American; and the Bronn, Shary, Konick, and Schultz, for the other side. The owners of such collections are anxious that all their work should not be scattered to the winds, and that the materials they have brought together should be kept as historical documents.

In the care of geological and palæontological collections the difficulties of preserving them are inconsiderable, the cost is not excessive, and there are not many troublesome questions likely to arise beyond that of space. When, however, we come to zoölogical materials, the difficulties are great. As far as the collections placed on exhibition are concerned, their deterioration is a mere question of time. The director of any museum must constantly replace his Birds and Mammals, renew the alcohol of his Fishes, Reptiles, and alcoholic Invertebrates, and renew all his Insects after a while. If the number of rooms devoted to the public is not too large, the expense seems warranted, if we are to judge of the interest taken as shown by the constantly increasing number of visitors on week-days as well as Sundays. It is when we come to the collections of a

perishable nature stored in the work-rooms devoted to special investigations that the cost of maintaining them may stagger the most enthusiastic collector.

Do the results justify such large expenditures? While we recognize the importance of keeping intact the historical collections, and take it for granted that this function is totally distinct from that other function, which museums are supposed to perform, of supplying special investigators materials for their study, it seems to me, nowadays, unreasonable to expect this of any museum. No naturalist who wishes to study fishes, except as regards their synonymy, will expect to find in any establishment, no matter what its resources may be, the necessary materials. He will be compelled to travel, to collect in the various fish-markets of the world, and to study his material on the spot. With the present facilities and the cost of travel, it would be far cheaper for an institution to supply the specialist with the necessary funds for such an investigation, if it be one of value and interest, than to go on for years spending in salaries of assistants, care of collections, interest on the cost of buildings, and so forth, sums of money which, if distributed to their ultimate object, would astonish the least prudent manager. Such accumulations of historical material are far too costly. The same sums spent in a different direction, in promoting original investigations in the field or in the laboratory, and in providing means for the publication of such original research, would do far more towards the promotion of natural history than our past methods of expending our resources.

There are stored in the cellars of the Museum immense collections of Fishes and Reptiles which have never been of use to any one except the assistants in charge of them. A very large part of this material, collected and maintained at great expense, ceases after a time to be of value for scientific purposes, and every year we are obliged to throw away as absolutely worthless a large number of specimens which cannot even be used up as students' material. One of the rooms in the cellar is filled with alcoholic Birds and Mammals, and with Vertebrate embryos, material which has become in a great degree useless for the purpose for which it was collected. The same may be said of the large alcoholic collections of Mollusks and of Crustacea. The latter, however, while perhaps not available for study, can hardly be

kept in a condition fit for examination in any other way. A large part of the collection of Radiates is likewise useless for any nice systematic work. The expense and care required for the maintenance of a large collection of Insects is well known; the incessant care of Dr. Hagen and his Assistant has alone kept ours from going to ruin, as so many other entomological collections have done, from their mere size. But its increase involves now an expenditure the Museum can ill afford. Of course, with ample funds and a large number of aids, there is no limit to the growth of an entomological department. Our ornithological collection and that of mammal skins can be kept within a reasonable expenditure from the method of storage adopted. The osteological collection, also, when once properly prepared, need not be a constant source of expense. The cost of maintaining such a collection as is now stored in the Museum has been for the past eight years at the rate of $24,000 a year, of which nearly $18,000 is for salaries. This is merely for the care and maintenance of the collection, and does not include the cost of placing any part of it on exhibition, or the cost of keeping those rooms open to the public.

For these reasons I have gone somewhat into detail to point out what seems to me to be the true policy of the institution for the future, — to reduce its expenditures and staff to the strict minimum compatible with the care of collections, and to expend its resources in supplying the material, books, and specimens needed for original investigation by the Professors and students of Natural History in the University, to whom the Museum should furnish in addition, in part or in whole, the means of publication in its Bulletins and Memoirs. While we have no cause to regret the publications which have been issued in connection with the Museum, yet they do not represent sufficiently the original work done by the teaching staff of the University and their students. In addition, it should grant other specialists, properly qualified, all the facilities they may desire for the study of the Museum collections, consistent with their safety.

That this prospective analysis is not out of place will appear from the fact that, whenever the original plan of the Museum building is carried out, it does not provide for more room than is likely to be needed by the various laboratories of the special

departments of Natural History established hereafter, together with such collections as, even with the most rigorous sifting, each will accumulate. The natural growth of comparative anatomy, ethnology, and archæology, and of the geological, geographical, and other biological departments, which will naturally centre in the Natural History square of the University, will tax its capacity to the utmost, if they have in the future a growth at all commensurate with that of these departments up to the present time.

ALEXANDER AGASSIZ.

CAMBRIDGE, October 1, 1884.

REPORT ON THE GEOLOGICAL DEPARTMENT.

BY JOSIAH D. WHITNEY, *Sturgis-Hooper Professor of Geology.*

DURING the year 1883–84 instruction was given by the Sturgis-Hooper Professor in Economical Geology, there being two lectures a week throughout the College year. The portion of the course relating to building-stones was given by Dr. Wadsworth. No instruction was given in lithology.

Some field-work was done by the Professor and his Assistant in various parts of New England and New York, in continuation of preparations making for future publications. The collections in lithology have not, however, been materially enlarged during the year.

A large portion of the time of the Sturgis-Hooper Professor has, during the year, been occupied with preparing for publication, putting in type, and issuing an extensive illustrated work in Ornithology, "The Water Birds of North America," of which the text was prepared by Messrs. Baird, Brewer, and Ridgway, as a continuation of work begun by the Geological Survey of California, and continued in "The Land Birds of North America," by the same authors. The illustrations of the Water Birds, having been left unfinished at the time of the stoppage of the California Survey (1874), were completed at the expense of the present writer, and after considerable delay the manuscript was also made ready by the authors. This manuscript having been examined by Mr. J. A. Allen, at the request of the Curator of the Museum, was strongly recommended by him for publication in the Memoirs of this institution. This arrangement was agreed to by the Curator, under the expectation that a considerable part of the expense thus incurred would be reimbursed to the Museum from the sale of copies to naturalists and sportsmen. The first volume has been on sale for some time,

and the second and final one will be offered to the public, with both colored and uncolored figures, within a week.

The work entitled "The Azoic System and its Proposed Subdivisions," noticed in the last Report of the Sturgis-Hooper Professor as being put in type, has now been completed and issued. It closes the first volume of the geological series of the Bulletin. This work has occupied a large amount of the time of the joint authors during the past three or four years. This was natural and necessary, since the task undertaken demanded the careful examination of all that had been published in this country and in Canada in regard to the older crystalline rocks of North America. A considerable amount of field-work also had to be done, with reference to certain important questions raised in connection with the undertaking. Although the record, as displayed in this volume, is not very flattering to American geologists, it is thought that the work was a necessary one, and that its value will be more and more appreciated as the discussion of the subjects here brought forward is carried on.

Another work of importance, begun by Dr. Wadsworth several years ago, has been so far carried towards completion that the first part, comprising about 250 pages, with eight chromolithographic plates, is now in type, and will be ready for distribution within a week or two. This work, which is entitled "Lithological Studies, a Description and Classification of the Rocks of the Cordilleras," forms the first part of Volume XI. of the Memoirs of the Museum. A few words may here be introduced in reference to the scope of the volume which has been so long in preparation.

The close of the California Survey left among the subjects demanding attention the classification and description of the collection of rocks which had been got together from every part of the Cordilleran region, including Mexico and Central America. To these collections were afterwards added others from various portions of the country, the whole making up a mass of material of very considerable extent and value. The task of describing this material was intrusted to Dr. Wadsworth, who had already begun those investigations upon the rocks of Eastern Massachusetts which have been of so much importance in throwing light upon the geology of that obscure and difficult region.

At the time the work on the Cordilleran collections began, "The Natural System of Volcanic Rocks" of Richthofen, and "The Microscopical Petrography" of the Fortieth Parallel Survey, were generally accepted as guides to the lithology of more recent volcanic rocks occurring in this country, as well as the older eruptive ones. But as Dr. Wadsworth's investigations progressed, it became evident that Richthofen's system was defective in its basis, as well as too limited in its scope to be a satisfactory guide in arranging the Cordilleran rocks. Moreover, it appeared, on carefully examining the collections of the Fortieth Parallel Survey and Professor Zirkel's work thereon, that this work was replete with errors of detail of the gravest character; while its leading ideas, although in large part identical with those of Richthofen, were at the same time decidedly less philosophical in character. These facts required an abandonment of the Fortieth Parallel results; although such material furnished by that survey as was of value could be freely used in endeavoring to arrive at a more satisfactory classification.

The results obtained by Dr. Wadsworth, so far as reached at that time were published by him in 1879, in the Bulletin of the Museum, under the title of "A Classification of Rocks." This paper led to much caustic public and private criticism, as well as efforts to interfere with the further prosecution of the investigations. These criticisms, and the answers thereto, will be found in various papers published in the Proceedings of the Boston Natural History Society, from 1881 on.

The work of the geologists and lithologists of the United States Geological Survey, quite recently published, however, sustains in a remarkable manner the conclusions formulated in Dr. Wadsworth's "Classification of Rocks"; although — owing to the bitterness engendered at the time of the first publication of that paper, when it was almost universally believed to be false in its conclusions, as it was most decidedly in conflict with the results obtained by two learned and able German professors — the later investigators in this field have not acknowledged the priority of Dr. Wadsworth's work, or given due credit to the Museum for the important results attained under its auspices.

While, in carrying on the task thus undertaken, the same general direction of thought has been followed of which the

“Classification of Rocks” is the exponent, Dr. Wadsworth has found it necessary to enter upon the discussion of other more general problems, so intimately connected with the subject in hand that they could not well be left unexamined. Among these problems were, 1st, the nature and origin of the older crystalline rocks; 2d, the structure and condition of the earth's interior; 3d, the nature and origin of meteorites; and 4th, the nature and composition of the rocks more basic than the basalts. The investigation of the first mentioned of these topics led to the publication of “Notes on the Iron and Copper Districts of Lake Superior,” as well as of numerous smaller papers, and finally to a work of larger scope — already mentioned — the joint production of the Sturgis-Hooper Professor and his Assistant, and entitled, “The Azoic System, and its Proposed Subdivisions.” The results of the examination of the second subject mentioned above were published in a communication which appeared in the American Naturalist; while the questions coming under the head of the third and fourth topics enumerated above were discussed in papers already noticed in previous Reports, and in others indicated in the list here appended.

Dr. Wadsworth's work on the Cordilleran collections began with the basaltic, andesitic, trachytic, and rhyolitic rocks; but it has seemed best to refrain from publishing these results until the more basic forms could be studied. Owing to the limited amount of material of the last-mentioned kind in the Museum collections, it became necessary to study the work of others, and unite the results thus obtained with those reached by the aid of our own collections, and the result is, that in systematically arranging the whole mass of material for publication, it has been found best to divide the proposed volume into three portions, as follows: —

1st. A general discussion of the principles of the work, and a study of the groups more basic than the basalts.

2d. The basalts and andesites.

3d. The trachytes, rhyolites, and jaspilites.

The chief portion of the second division of the work has been lying in manuscript since 1879, and the first part is, as already mentioned, nearly ready for delivery.

List of Papers published by Dr. Wadsworth during the Year.

1. The Fortieth Parallel Rocks. Proc. Bost. Soc. Nat., 1883, XXII. 412–432.

2. On the Evidence that the Earth's Interior is Solid. American Naturalist, 1884, XVIII. 587–594, 678–686, 767–773.

3. Lithology of some Cordilleran Volcanoes. Ibid., pp. 526–528.

4. Methods of Instruction in Mineralogy. Pop. Sci. Monthly, 1884, XXIV. 754–759.

5. Descriptive Catalogue of One Hundred Thin Sections of American and Foreign Rocks, for the Use of Students of Microscopical Lithology. 20 pp.

6. Notes on the Rocks and Ore Deposits in the Vicinity of Notre Dame Bay, Newfoundland. Am. Jour. Sci., 1884, (3), XXVIII. 94–104.

7. A Microscopic Study of some South Wales Rocks. Trans. Am. Inst. Mining Engineers, 1883, XI. 499–501.

8. The Theories of Ore Deposits. The Nation, Feb. 7, 1884.

9. The Lateral Secretion Theory of Ore Deposits. Eng. and Mining Journal, 1884, XXXVII. 364, 365.

10. Résumé of the "Mineral Resources of the United States." Science, 1883, II. 413, 414.

11. The Maine Building Stones. Ibid., pp. 771, 772.

12. The Olivine Rocks of North Carolina. Ibid., III. 486, 487.

13. The Relation of the "Keweenawan Series" to the "Eastern Sandstone." Ibid., p. 553.

14. Parallel Development of Personal Names and of Natural History Nomenclature. Ibid., IV. 109, 110.

15. Some United States Geologists and the Propylite Question. Ibid., p. 111.

REPORT ON THE INSTRUCTION IN BIOLOGY.

By Professors W. G. Farlow, Walter Faxon, and E. L. Mark.

The course in the elements of Biology (N. H. 5), given by Professors Farlow and Faxon, was attended by thirty-two students, — ten members of the Senior College Class, fifteen Juniors, one Sophomore, four students of the Lawrence Scientific School, and two special students. The instruction was given by lectures and laboratory work, six hours a week being devoted by each student to the laboratory. For the first half-year, the botanical part of the course was given by Professor Farlow. During the second half-year, the principles of zoölogy were taught by means of dissection of forms of animals typical of the chief groups, and by lectures on their anatomy and development. Mr. G. W. Perkins assisted in the direction of the laboratory work of this course. The larger space and increased facilities for work afforded by the new laboratory relieved the instructors from the necessity of dividing the class into sections for working at different hours, as was necessary in the old laboratory. The ample provision for heating the laboratory made it possible to continue the microscopical work through the whole winter without interruption. This has not been the case in previous years, when, during severe weather, it was necessary to abandon work with the microscope, and dissections, and to substitute lectures in their place. The certainty that the laboratory will hereafter always be comfortably warmed will enable the instructors to arrange their lectures and corresponding laboratory work more methodically than heretofore.

The course in Advanced Zoölogy was pursued by fifteen students, — ten Seniors, four Juniors, and one member of the Scientific School. The early part of the year was spent on the Mollusca; but the greater part of the time was devoted to the comparative anatomy of the Vertebrata.

During the second term instruction was given to Natural History 7 in Professor Farlow's own working-room at the Museum. This was necessary in consequence of lack of facilities for illustrating the study of cryptogams at the Botanic Garden. Hereafter, however, this class will be furnished with a room in Harvard Hall, thus leaving Professor Farlow's room free for the arrangement of collections, and such work as may be done by persons doing special work in cryptogamic botany.

During the academic year 1883–84 the general lectures in Zoölogy by Dr. Mark were given for the first time in the new lecture-room at the Museum, which affords ample accommodation for even larger classes than those of the past few years. The course was attended by one hundred and eleven students, of whom one hundred and four were in attendance during the whole year, and seven for somewhat more than half the year. Of those who completed the course twenty-three were Seniors, thirty-four Juniors, thirty-eight Sophomores, one Freshman, four special students, and four Scientific School students.

Professor Mark has given assistance during the year to two students engaged in special zoölogical investigations. The work of one of them, an undergraduate, is not yet completed. The other person, to whom the privileges of the Museum were extended by the Curator, has produced a paper which is now in press, and will soon appear in the Proceedings of the American Academy: "On the Anatomy and Histology of Aulophorus vagus. By J. E. Reighard."

The new Zoölogical Laboratory affords excellent facilities for the prosecution of the more delicate histological and embryological studies, and has been found by a year's trial to meet every essential requirement of such a work-room.

The paper previously reported as prepared last year, by William Patten, has recently been published with some additions, in the Quarterly Journal of Microscopical Science, London, Vol. XXIV., 1884.

REPORT ON GEOLOGY AND PALÆONTOLOGY.

BY PROF. N. S. SHALER.

DURING the academic year 1883–84 the following courses of instruction was given in the Geological and Palæontological Laboratory by N. S. Shaler and William M. Davis: —

1. (N. H. 1.) A course in Physical Geology and Meteorology, by W. M. Davis, three hours a week. Attended by forty-one students.
2. (N. H. 4.) A course in Elementary Geology, by N. S. Shaler, two lectures a week, and one day of field excursion during the time when field-work was possible. Attended by one hundred and five students.
3. (N. H. 8.) A course in Advanced Geology, by N. S. Shaler and W. M. Davis, two lectures each week, together with assigned field-work, which was conducted by Mr. Davis. In the winter season this field-work was replaced by the study of models and geological reports in the laboratory. This course was attended by forty-five students, who had previously passed a satisfactory examination in elementary geology.
4. (N. H. 14.) A course in Palæontology, by N. S. Shaler, two lectures each week, with laboratory work, principally in the Synoptic Room of the Museum, and also with assigned theses. Attended by fifteen students.
5. (N. H. 16.) A course in field-work designed to afford special training in the processes of geological surveying, by N. S. Shaler and W. M. Davis. Attended by four students.
6. (N. H. 17.) A course in Historic Geology, designed to give training in the determination of geological horizons, by N. S. Shaler. Attended by two students.

In addition to the foregoing courses of instruction, a number of special meetings of the students and instructors in this department were held during the winter months. These meetings

were designed to afford a training such as is given in the Gymnasia of the German Universities.

During the summer of 1884 eight students who had pursued courses in the laboratory were guided in the prosecution of field-work in geology and palæontology. In the spare time of the instruction period, and during the vacations, the following additional work has been done.

By N. S. Shaler, the publication of a "First Book in Geology," with instruction for teachers, 325 pages. The completion of certain work in connection with the Kentucky Geological Survey. The prosecution of a geological study of the Narragansett Coal-field, including the supervision of a systematic exploration of portions of this field by means of the diamond drill; and, during the summer months, a study of the coast line of Passamaquoddy Bay. In the last-named work, over one hundred miles of shore line were carefully examined, with interesting results; a report of this work will appear in the publications of the United States Geological Survey.

The papers published by Mr. W. M. Davis during the past year are: —

1. Beecraft's Mountain and the Nonconformity at Rondout, N. Y. Amer. Journ. Sci., XXVI., 1883, pp. 381–395.

2. Whirlwinds, Cyclones, and Tornadoes. Boston, 1884. Reprinted from Science, Vols. II. and III.

3. Meteorological Charts of the North Atlantic. Science, III., 1884, pp. 593–597, 654–657.

4. The Winds and Currents of the Equatorial Atlantic. Amer. Meteorol. Journal, June, 1884.

5. The Relation of Tornadoes to Cyclones. Amer. Meteor. Journal, August, 1884.

6. Gorges and Waterfalls. Amer. Journ. Sci., XXVIII., 1884, pp. 123–132.

REPORT ON MAMMALS AND BIRDS.

By J. A. Allen.

These departments remain nearly as indicated in the last Report, there having been comparatively few additions or other changes during the last year.

To the collection of Mammals have been added nineteen mounted specimens, three skins, and one mounted and eight unmounted skeletons. Of noteworthy pieces are a female gorilla and a black-tailed deer (*Cariacus columbianus*), the latter contributed by Professor Baird; also, a skeleton of a whale.

The collection of Birds has been increased by the addition of sixty-eight mounted specimens (fifty-eight species) and one hundred and seven skins (sixty-one species); the latter mainly to fill deficiencies in the North American collection. There have also been added three mounted and three unmounted skeletons. The Birds in the Systematic, South American, and Australian Rooms have been labelled, and considerable progress has been made in the preparation of the systematic or index catalogue of the skins.

REPORT ON THE REPTILES AND FISHES.

By Samuel Garman.

In these departments the number of specimens on exhibition has been considerably increased. The exhibit for the Europeo-Siberian room has been selected, mounted, and put in position, and many additional specimens have been placed in the other rooms. The loss by evaporation from the jars on the shelves has been small. A gratifying reduction of the bulk of the collections in the storage-rooms has been rendered possible by the number of identifications. Quantities of duplicates and badly preserved specimens have been thrown away. Convenience in handling and in storing the reserves has been greatly enhanced by the space formerly occupied by the thousands of specimens that have gone out. Since the thorough renovation of a couple of years ago, comparatively little change is to be noticed in the contents of the storage-tanks, cans, and jars.

Receipts. — The fishes of the first Blake Expeditions have been returned by Dr. Steindachner. A desirable lot was secured by purchase from Prof. Ward. It included fishes, selachians, batrachians, and reptiles. Among them was a fine series of sea snakes, and the strange shark, *Chlamydoselachus anguineus*, the type of a new order. This selachian derives an especial importance from the fact that it is the only known living representative of the Cladodonts, so numerous in the Middle Devonian and the Subcarboniferous. It possesses the distinction at present of being "the oldest living type of Vertebrate." A careful study of this species has been made, and is now being illustrated in an extensive series of drawings by the Museum artist, Mr. Roetter. From S. H. Sommers, Esq., has been received a collection of fossil fishes from the Twin Creek shales of Wyoming. We are indebted to the Fish Commissioners of Massachusetts and New Hampshire for a large series of young

trout and salmon, showing their various malformations and monstrosities. Mr. Luther Hays and Colonel E. B. Hodge have interested themselves in our behalf so much as to send in some of the largest and finest specimens of trout taken during the season. Mr. George R. Allaman contributes a fine collection of living reptiles. Some rare fishes, *Chologaster*, and batrachians were received in exchange from H. Garman, Esq. Prof. F. W. Putnam has made several donations of reptiles and batrachians. From Prof. Alexander Agassiz a number of young fishes have been received; from Mr. S. F. Denton, several New Guinea lizards; from N. Vickary, Esq., several reptiles; from Dr. Fewkes, some larval batrachia; and from Miss Isabel Batchelder, a species of Prionotus.

Shipments. — The fishes of the Blake Expeditions returned by Dr. Steindachner were forwarded to Prof. Goode. The fishes of the United States Exploring Expedition were sent to the Smithsonian Institution. There were also sent out as exchanges some seventy-five species, a hundred and thirty-four specimens, of fishes, to Prof. Jordan; nine specimens of reptiles and batrachians, to Mr. H. Garman; specimens of Siren, Amphiuma, and Amblystoma, to Prof. Moseley; and a number of cans and jars, to Mr. M. A. Lawson, of Ootocamund. A lot of live reptiles were consigned to the Zoölogical Society of London.

The publications of the year from these departments includes: —

"A List of the Species of Reptiles and Batrachians occurring North of the Isthmus of Tehuantepec, with References."

"An Extraordinary Shark, *Chlamydoselachus*."

"A Species of *Heptabranchias* supposed to be New." Published in the Bulletin of the Essex Institute.

"The Reptiles of Bermuda." In Bull. 25, U. S. Nat. Mus.

Besides the foregoing, there have been published articles on "A Peculiar Selachian," and "The oldest living Type of Vertebrata," in "Science," and various other articles, reviews, and book notices. The volume on "North American Reptiles and Batrachians," though printed last year, has only recently been received and sent out by the Museum.

REPORT ON THE ENTOMOLOGICAL DEPARTMENT.

By Dr. H. A. Hagen.

The collection of North American Coleoptera, from the late Dr. John L. Le Conte, of Philadelphia, Pa., — bequeathed to the Museum, — is the most prominent addition. The collection fills three cabinets, with two hundred and eight boxes, and thirty-three larger boxes besides, seven of them not yet delivered. The collection represents the well-used tool of a hard and incessant worker.

The collection is indeed very large and important, and has been carefully compared with the Doctor's works by the Assistant through the whole month of August. Of the types thirteen are wanting: two Mexican species given by the Doctor to the Philadelphia Entomological Society; two were lost on the journey to Europe; eight, recognized later as synonyms, are probably present, but without label; one, *Myodites Zeschi*, is not yet found.

With this collection are now returned to the Museum the types of Melsheimer, Ziegler, and Say, selected by Dr. J. L. Le Conte from the collections of Melsheimer and Ziegler when they were purchased for the Museum.

In the printed catalogue, every species and the number of specimens have been checked off by the Assistant as a provisional catalogue. The full number cannot be given before the whole collection is delivered.

A collection of the early stages of Lepidoptera, two hundred and twenty species, all new to the Museum, was bought from Dr. Staudinger, Dresden, Saxony. A new arrangement of the biological collection of the Lepidoptera was made necessary by this addition. This part fills now seven cabinets, with one hundred and twenty-six boxes. The biological collection of Lepidoptera is certainly the richest of this kind in existence.

A new arrangement of the biological collection of the Coleoptera, to introduce the collection presented by Professor Schaupp, had to be postponed for want of cabinets.

A large collection of Neuroptera from Samana Bay, Haiti, made by Mr. Frazer, was bought and presented to the Museum.

A large lot of Odonata, from the North Guinea Archipelago, Central Asia, South Africa, Peru, and Brazil, was bought and presented to the Museum.

Numerous additions by private students, or by exchange, have, as usual, enlarged the collection. By exchange were added Lepidoptera, from Arizona and Himalaya, by Mr. B. Neumoegen, New York, and Neuroptera, by Mr. Aaron, Philadelphia.

The collection has been largely used both here and abroad. The Myriapodes are still in Dr. Meinert's hands, half of them — the Chilopoda — ready for publication. North American Arachnids are still in the hands of Count Keyserling. The second volume of his Spinnen Amerika, Theridiidæ, Nurnberg, 1884, is just published, a handsome quarto volume of 221 pages and 10 colored plates. Of the Scorpions a dozen Unica are still in Mr. Simon's hands, in Paris, for publication.

The Ephemerina have been returned by Mr. Eaton from England. Two parts of his splendid monograph are published; with the third concluding part, the monograph will fill a whole volume of the Transactions of the Linnæan Society of London. On nearly every page the material supplied by the Cambridge collection is mentioned.

The larger part of the North American Tineinæ have been in the hands of Prof. H. Frey, in Zürich, Switzerland. They were safely returned with the notes of Prof. Frey. A prepared publication had to be postponed by his illness.

Mr. P. R. Uhler has studied and determined the Hemiptera collected in 1882 in Washington Territory.

Mr. J. B. Smith, of Brooklyn, New York, has studied and published the Satyridæ collected in 1882 in Washington Territory (in the Bulletin of the Brooklyn Entomological Society).

Mr. L. Brunner has studied the Orthoptera collected in 1882 in Washington Territory.

The Assistant has published a number of smaller papers; among them, the remarkable discovery that the Hessian fly was known by this name, and by its ravages, in 1768, long

before the Revolution ; and a paper on the law against grasshoppers in the sixteenth century. Both papers are published in "Science." Farther, the discovery of two entomological papers by Th. Say, not included in Le Conte's edition, in Psyche ; the types of Gelechia in the collection of the Museum, in Papilio ; and several biological notes in the Canadian Entomologist.

The principal scientific work was done for the monograph of the early stages of the Odonata. By numerous additions, and generous help here and abroad, the material is now so enlarged that the first part (which is ready for publication), the Gomphina, is many times richer than the monograph published ten years ago.

The Lamellicornia of the general collection have been rearranged, and fill three cabinets.

REPORT ON THE CRUSTACEA.

By Walter Faxon.

The principal additions to this collection during the past year have come through a system of exchanges carried on in connection with a revision of the Astacidæ, prepared by the Assistant. Almost every described species of Astacid of the Northern hemisphere is now represented in the Museum collection.

A collection of Mediterranean Sea Crustacea has been purchased from the Zoölogical Station at Naples.

REPORT OF THE CONCHOLOGICAL AND PALÆONTOLOGICAL DEPARTMENTS.

By Charles E. Hamlin.

The chief additions made in the department of Palæontology, since the date of the last annual Report, are Fossil Vertebrates collected by Messrs. S. Garman, H. C. Clifford, G. R. Allaman and L. Hollywood, from the Jurassic, Cretaceous, and Tertiary strata of Kansas, Nebraska, Dakota, and Wyoming. Of these collections provisional disposition has been made, until cases shall be provided for their distribution and arrangement. Since they will probably be more fully noticed in the future reports upon Mammals, Reptiles, and Fishes, no further statement is here required.

To the series of Fishes from the Lower Carboniferous of Scotland, last year purchased of the collector, Mr. Thomas Stock of Edinburgh, additions have this year been made through the same collector.

The systematic collection of Fossil Plants, including the American series determined in former years by Mr. Lesquereux, as well as the European series, has been put in order and transferred for storage to cases in the Synoptic Room, where they have been arranged in the order of the several geological formations which they represent.

The collections of Invertebrate Fossils, heretofore stored in the unfinished eastern attic, have been removed to the first floor, and the Tertiary, Mesozoic, and part of the Palæozoic collections have been arranged in systematic order in permanent cases recently constructed for them.

The great collection of Fossil Invertebrata, made by, and in 1880 purchased of, Mr. C. B. Dyer of Cincinnati (since deceased), which has hitherto remained in the packages, has been unpacked, and, after preliminary arrangement, placed in cases

now first made ready for it. The greater part of this exceedingly rich collection consists of specimens from the Cincinnati Limestone, the Niagara strata of Waldron, Ind., and the Subcarboniferous of Crawfordsville, Ind.

Two boxes of Paradoxides, Conocephalites, Beyrichia, Leperditia, etc., have been forwarded for study to Dr. C. D. Walcott of the National Museum at Washington.

My time having been chiefly occupied with the Palæontological collections, comparatively little work has been done in the Conchological department.

For the large and fine collection of recent marine shells, from Tasmania, and of Palæozoic and Tertiary Mollusca, from Tasmania and Southern Australia, received at the close of the last academic year from Lieut. C. E. Beddome, of Hobart, there have been sent in return a full series of recent Lamellibranchiate shells.

A few recent shells have been delivered to Prof. Alfred C. Haddon, of the Royal College of Science, Dublin, as the beginning of an exchange.

In connection with the work of the year has been published "Results of an Examination of Syrian Molluscan Fossils, chiefly from the Range of Mount Lebanon. By Charles E. Hamlin." 4to, pp. 68, 6 Plates. Mem. Mus. Comp. Zoöl., Vol. X. No. 3.

REPORT ON THE RADIATES.

By J. Walter Fewkes.

Since the last Annual Report, the collection of alcoholic Radiates has been brought together in a room in the cellar, which is now taken up by them and the alcoholic collection of Sponges.

Representative genera of Corals and Sponges have been picked out from the general collection of dried material for future exhibition in the Faunal Rooms. These now await mounting, after which they can easily be put on exhibition in places already prepared for them.

A collection of Coral Sands and Rocks illustrating the formation of the West Indian and Floridan coral islands has been sent to the Brussels Museum.

Several trays filled with specimens of dried Ophiurans and additional dried Sea Urchins, many from the deep seas, have been placed with the other dried Echinoderms.

A collection of Echinoderm parasites, Myzostomidæ, collected by the Blake and Hassler Expeditions, and described by Dr. L. V. Graff in Vol. XI. No. 7, of the Bulletin of the Museum, have been returned.

One or two identified specimens of new Echinoderms, collected by the United States Fish Commission, have been added to the general collection.

REPORT ON THE LIBRARY.

By Miss F. M. Slack.

During the year ending September 1, 1884, the Library has been increased by 565 volumes, 1234 parts, and 775 pamphlets.

	Volumes.	Parts.	Pamphlets.
Gift	15	124	128
Exchange	117	442	82
Purchase	154	601	157
A. Agassiz	47	58	408
Museum Publications	3	9	
Binding Parts and Pamphlets	229		
	565	1234	775

The whole number of volumes now in the Library (exclusive of pamphlets) is 16,657.

[A.]

PUBLICATIONS

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

FOR THE ACADEMIC YEAR 1883-84.

Of the Bulletin.

Vol. VII., completing the volume: —

No. 11. The Azoic System and its Subdivisions. By J. D. Whitney and M. E. Wadsworth. xvi. and 335 pp. August, 1884. $2.50.

Vol. XI.

No. 5. Reports on the Results of Dredging by the U. S. C. S. Steamer "Blake." — XXV. Supplementary Report on the "Blake" Cephalopods. By A. E. Verrill. 12 pp. 3 Plates. October, 1883. 40 c.

No. 6. Descriptions of Two Species of Octopus, from California. 8 pp. 3 Plates. October, 1883. 40 c.

No 7. Reports on the Results of Dredging by the U. S. C. S. Steamer "Blake." — XXVI. Verzeichniss der von den United States Coast Survey Steamers "Hassler" and "Blake," von 1867 zu 1879, gesammelten Myzostomiden. Von Dr. L. v. Graff. 9 pp. November, 1883. 10 c.

No. 8. A Supplement to the Fifth Volume of the Terrestrial Air-Breathing Mollusks of the United States and adjacent Territories. By W. G. Binney. 22 pp. 4 Plates. December, 1883. 60 c.

No. 9. Studies from the Newport Marine Zoölogical Laboratory. — XXII. On the Development of certain Worm Larvæ. By J. W. Fewkes. 42 pp. 8 Plates. December, 1883. $1.25.

No. 10. Bibliography to accompany "Selections from Embryological Monographs, compiled by A. Agassiz, W. Faxon, and E. L. Mark." — III. Acalephs. By J. W. Fewkes. 30 pp. July, 1884. 30 c.

(Vol. XI. *to be continued.*)

Of the Memoirs.

Vol. VIII., completing the volume: —

No. 3. North American Reptiles. By S. Garman, in Connection with the Kentucky Geological Survey, N. S. Shaler, Director. 200 pp. 9 Plates. [Issued by the Museum, July, 1884.] Apply to Prof. N. S. Shaler.

Vol. X.

No. 2. On a Species of Fossil Dog, by J. A. Allen. (In press.)

No. 3. Results of an Examination of Syrian Molluscan Fossils, chiefly from the Range of Mount Lebanon. By C. E. Hamlin. 68 pp. 6 Plates. April, 1884. $2.50.

(Vol. X. *to be continued.*)

Vol. XI.

No. 1. Lithological Studies, by M. E. Wadsworth. (In press.)

Vols. XII., XIII. The Water Birds of North America. Vol. I., xi. and 537 pp.; Vol. II., 552 pp. With numerous Wood-cuts in the Text. By S. F. Baird, T. M. Brewer, and R. Ridgway. Issued in Continuation of the Publications of the Geological Survey of California, J. D. Whitney, State Geologist. April and August, 1884. For sale by Little, Brown, & Co., Boston, Mass.

Also preparing: —

Illustrations of North American Marine Invertebrates, from Drawings by Burkhardt, Sonrel, and A. Agassiz, prepared under the Direction of L. Agassiz. Selections from Embryological Monographs, compiled by A. Agassiz, W. Faxon, and E. L. Mark. Papers by Prof. E. Ehlers on the Annelids of the Straits of Florida, dredged by Messrs. Pourtalès and Agassiz; in Connection with the Geological Survey of Kentucky, by Prof. N. S. Shaler, on the Brachiopoda of the Ohio Valley; by A. Hyatt, on Cephalopods; by E. L. Mark, on the Development of Arachnactis; by M. E. Wadsworth; by Walter Faxon, on Astacidæ; and by A. Agassiz and C. O. Whitman, on the Embryology of Bony Fishes. Reports on the Dredging Operations in Charge of Alexander Agassiz, by the U. S. Coast Survey Steamer "Blake," for 1877, 1878, 1879, and 1880. H. B. Brady (Foraminifera), P. H. Carpenter (Crinoidea), W. H. Dall (Mollusks of the Gulf of Mexico and the Caribbean Sea), G. B. Goode and T. H. Bean (East Coast Fishes and Fishes of the Gulf of Mexico and the Caribbean Sea), C. E. Hamlin (East Coast Mollusks), A. A. Hubrecht (Nemerteans), A. Milne-Edwards (Crustacea), J. Murray (Sea Bottoms), E. Perrier (Starfishes), A. E. Verrill (Alcyonaria), and H. Théel (Holothuroidea).

[B.]

INVESTED FUNDS OF THE MUSEUM.

In the hands of the Treasurer of Harvard College, Sept. 1, 1884.

Sturgis-Hooper Fund	$100,000.00
Gray Memorial Fund	50,000.00
Agassiz Memorial Fund	297,933.10
Teachers' and Pupils' Fund	7,594.01
Permanent Fund	117,469.34
Humboldt Fund	7,740.66
	$580,737.11

The payments on account of the Museum are made by the Bursar of Harvard College on vouchers approved by the Curator. The accounts are annually examined by a committee of the Museum Faculty. The only funds the income of which is restricted, the Gray and the Humboldt Funds, are annually charged in an analysis of the accounts with vouchers to the payment of which the income is applicable.

The income of the Gray Fund can be applied to the purchase and maintenance of collections, but not for salaries.

The income of the Humboldt Fund can be applied for the benefit of one or more students of Natural History.

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